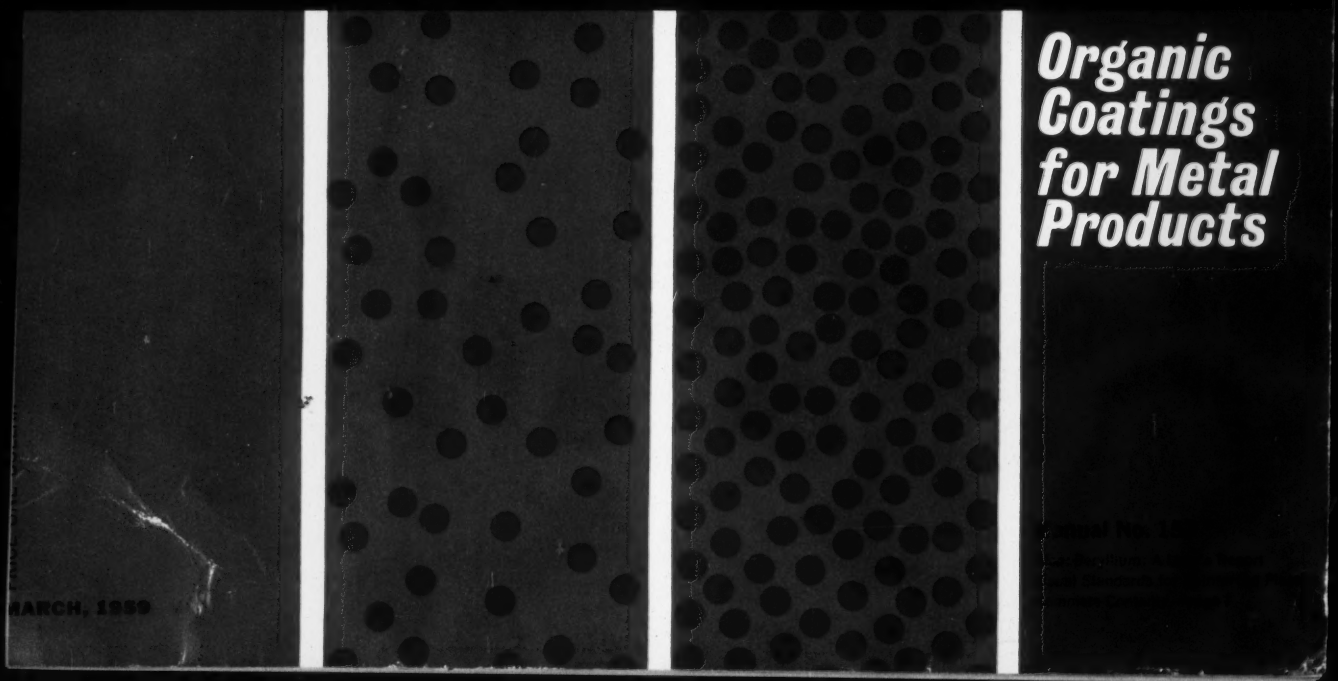
Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

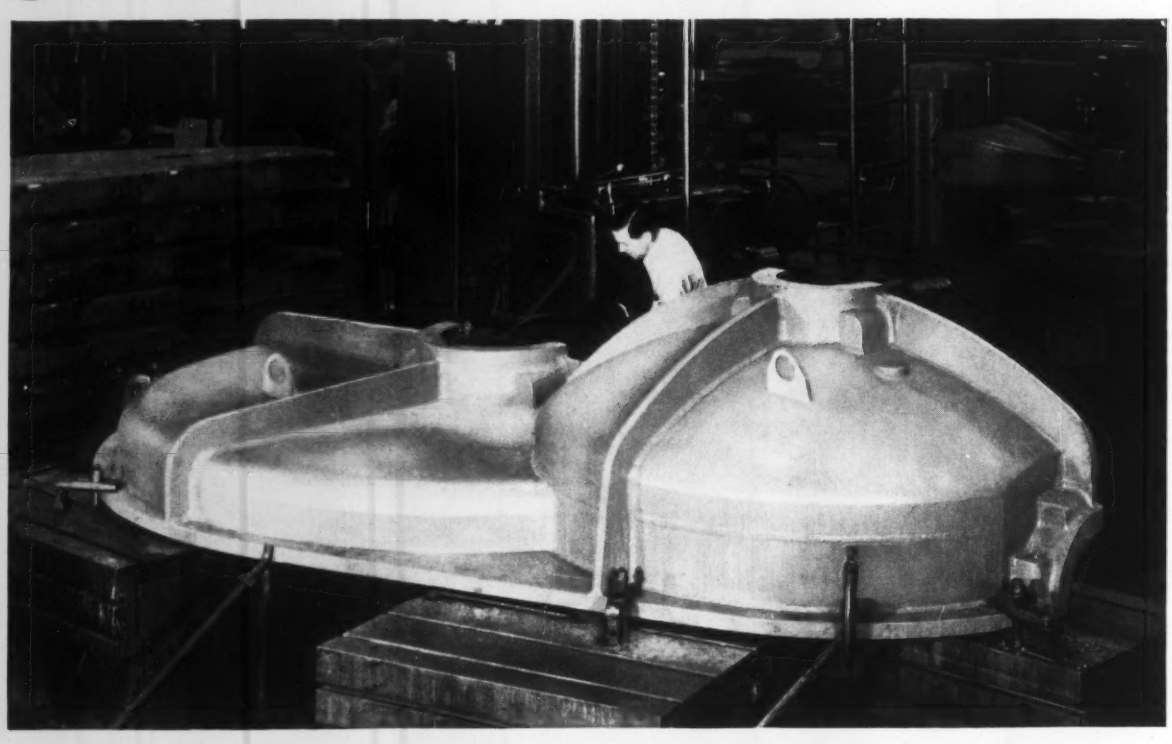
SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



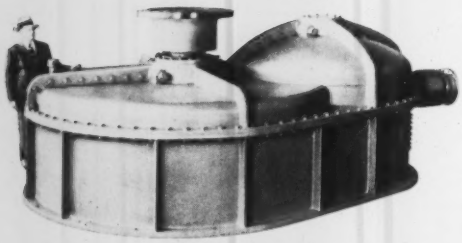
Organic Coatings for Metal Products

MARCH, 1959

STEEL-WELD FABRICATION . . .



PRECISION WELDMENTS Fabricated and Machined to Specification!



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Materials in Design Engineering, *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

MARCH 1959
VOL. 49, NO. 3

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Made by a new process, they make it possible to eliminate heat treating in many applications

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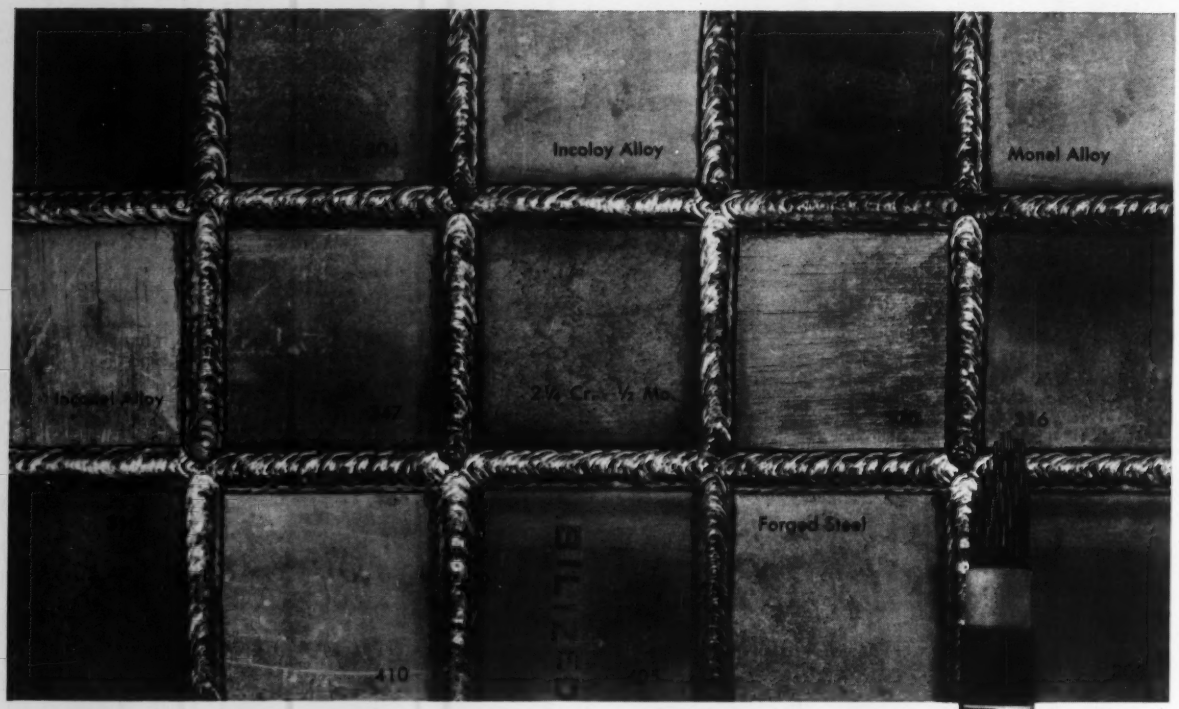

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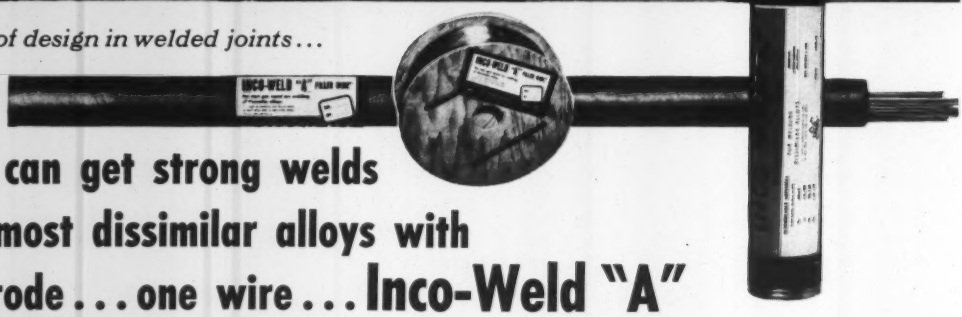

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Carbon Steel to Monel Alloy	.078"	10% Ni-Clad-Steel to 10% Ni-Clad-Steel	¼"
Carbon Steel to Inconel Alloy	⅜"	3½% Ni-Steel to 3½% Ni-Steel	½"

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What's new IN MATERIALS

...AT A GLANCE

Foamed nickel, copper and cast iron now join aluminum (see M/DE, Nov '57, p 200) as rigid, low density foamed materials. The three foamed metals, still in the development stage, are said to be nine times lighter than solid metals, and can be molded into practically any shape. Potential uses include jet engine and electrical parts. (More details next month.)

Source: General Electric Co., Aircraft Gas Turbine Div., Flight Propulsion Laboratory, Cincinnati, Ohio.

The first nitrile silicone rubber compound, a 60-durometer, relatively low modulus stock, is now available in evaluation quantities. It is called NSR-X5602. Nitrile silicone rubber, introduced last fall (see M/DE, Oct '58, p 139), has good resistance to oils, fuels and solvents, and withstands temperatures from –100 to over 500 F. Two other nitrile silicone rubber products are scheduled for the market later this spring. (More details next month.)

Source: General Electric Co., Silicone Products Dept., Waterford, N. Y.

A new ferrous material with a high elastic modulus (28×10^6 psi) may someday replace plain steel in forgings and permit greater design flexibility of castings. Still in the development stage, the material is made by innoculating a low carbon, high silicon-iron composition with boron and tellurium. The material has better machinability and castability than steel, and equals steel in strength.

Source: General Motors Corp., General Motors Bldg., Detroit 2.

A high quality, distortion-free glass has been developed in England. The new material, now available in limited quantities, is said to combine the high surface finish of sheet glass with the flatness and freedom from distortion of plate glass. Called Float glass, the product is made by a continuous process in which a ribbon of glass is passed from a furnace and floated on the surface of molten metal.

Source: Pilkingtons Canada Ltd., Toronto, Ontario, Canada.

An air hardening, high strength steel has been developed for jet aircraft and other high temperature applications. The material is said to resist softening after continuous exposure to temperatures up to 1000 F, and to have good ductility and toughness at tensile strength levels up to 300,000 psi. The steel, a manganese-chromium-molybdenum-vanadium alloy, has 140,000 psi ultimate tensile strength and 105,000 psi yield strength at 1100 F. (More details in a forthcoming issue.)

Source: Latrobe Steel Co., Latrobe, Pa.

Fluorocarbon plastics can be made bondable and dyeable by using a new radiation grafting technique that changes the surface characteristics of the plastic being treated. Radiation treated fluorocarbon plastics parts are said to keep their adhesive properties at temperatures up to 270 F. The radiation technique turns out

bondable parts at much lower costs than parts produced by conventional heat treating and chemical immersion techniques. (More details next month.)
Source: Radiation Applications, Inc., 370 Lexington Ave., New York City.

Rhenium metal is now available as rod, wire and strip in production lot quantities. The metal holds great promise as a welding material for molybdenum, and as a material for electrical contacts, thermocouples and electronic tube filaments. Rhenium metal is produced by powder metallurgy techniques.
Source: Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Conn.

A heat resistant transparent acrylic plastic is now available in limited quantities. The new material has mechanical and optical properties similar to those of polymethyl methacrylate, but a heat distortion point about 50° F higher (about 250 F at 264 psi). The acrylic is said to keep its water-white transparency after continuous immersion in boiling water.
Source: J. T. Baker Chemical Co., Phillipsburg, N. J.

Photoformed molybdenum electronic parts are now commercially available. The photoformed parts, compared with punched or stamped electronic parts, require no expensive tooling and can be made to dimensional tolerances of ± 0.0005 in. on parts having hole dimensions up to 0.025 in. Development work is now going on in producing photoformed electronic parts of tungsten and tantalum.
Source: Buckbee Mears Co., Toni Bldg., St. Paul 1, Minn.

High strength steels can be protected from corrosion without danger of hydrogen embrittlement by using vacuum deposited cadmium coatings. Parts vacuum coated with cadmium have also passed 96-hr salt spray tests without a trace of corrosion. The vacuum coatings are expected to be used on such aircraft parts as landing structures, control parts and threaded fasteners. The producer says vacuum deposited cadmium coatings compare favorably in cost and quality to electrodeposited coatings. (More details next month.)
Source: NRC Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass.

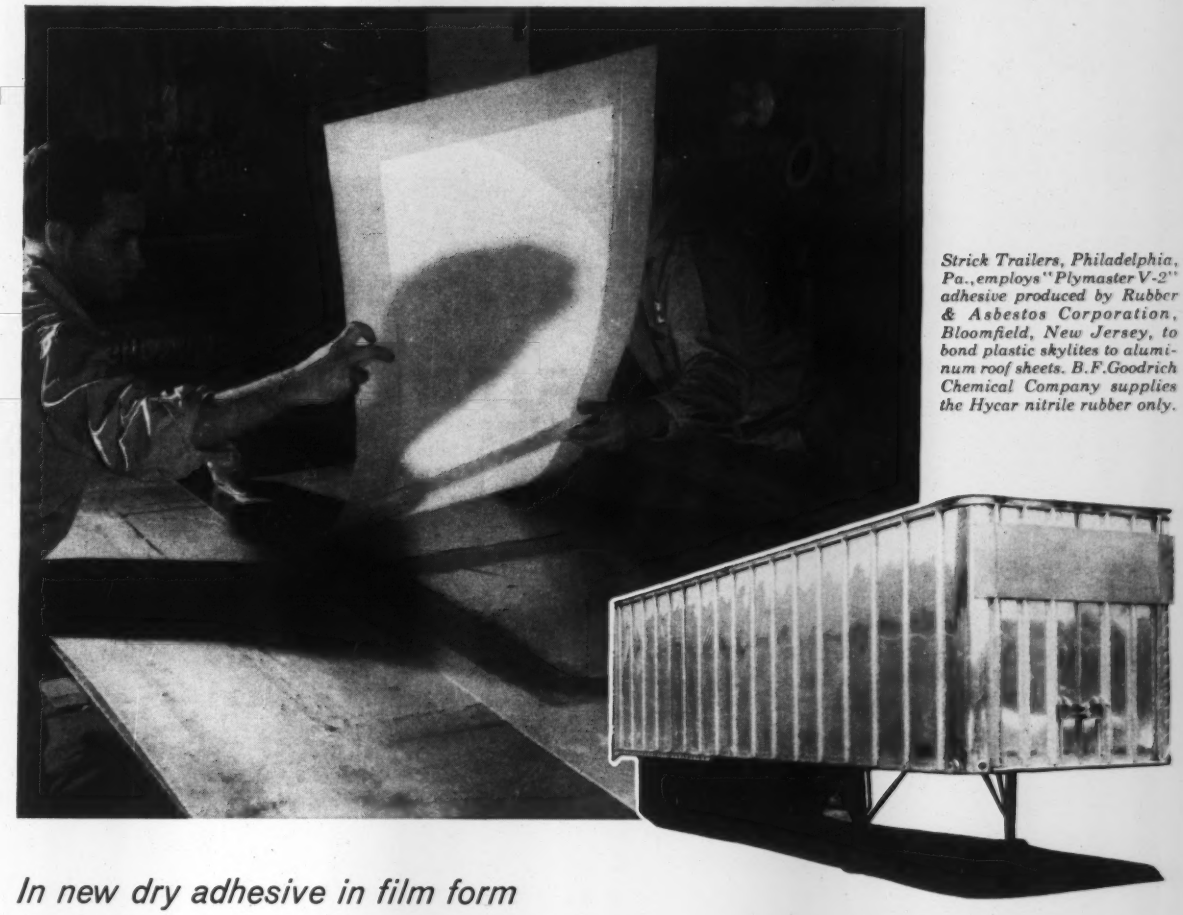
Look for new and interesting lead materials to make their appearance in the next few years. Already in the planning stage are: *fiber and metal-reinforced lead alloys* that will be much stronger than unreinforced lead, yet will retain lead's desirable properties; and *lead castings* that will be made by a continuous process. Also look for the use of lead coatings to increase heat emissive properties of other materials, and increased use of lead-containing porcelain enamels on steel.
Source: Lead Industries Assn., 60 E. 42nd St., New York 17.

Two new heat resistant alloys look promising as low cost materials for use in gas turbine engines. The developer has not revealed composition of the alloys, but does say they contain no critical elements. One alloy is said to have excellent resistance to oxidation at temperatures above 2000 F, and can be rolled, cast, forged and formed at normal working temperatures.
Source: Chrysler Corp., Detroit 31.

Turn to page 133 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



Strick Trailers, Philadelphia, Pa., employs "Plymaster V-2" adhesive produced by Rubber & Asbestos Corporation, Bloomfield, New Jersey, to bond plastic skylites to aluminum roof sheets. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber only.

In new dry adhesive in film form

Hycar rubber speeds and simplifies bonding

Mass-production bonding of flat surfaces as unlike as plastic and aluminum demonstrates the efficiency of this new dry adhesive in film form. It uses Hycar nitrile rubber to produce a bond between plastic skylites and aluminum roof sheets on both trailers and truck bodies. The adhesive manufacturer says Hycar provides a higher combination of cohesion and adhesion strengths than any other copolymer tested.

The adhesive comes in rolls from which sheets can be cut to exact size. No need for expensive liquid-handling equipment. You get a much cleaner, faster operation. The film adhesive can be reactivated with common solvents, heat or pressure to achieve tensile strengths as high as 1500 psi.

The exceptional qualities of Hycar nitrile rubber have led to produce improvements in many fields. For more information, write Dept. CL-1, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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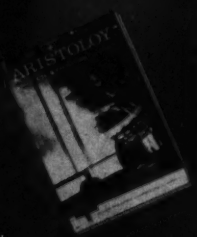

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MATERIALS AT WORK

...AT A GLANCE

Superalloy hook catches jets

A hook made of a high strength, high temperature steel alloy (A-286) is helping student jet pilots make better landings on carrier decks. The 76-in. shank and hook, which looks like a mosquito's stinger, is attached to the aft end of the plane. When landing, the pilot releases the hook which engages a steel cable on the flight deck and brings the aircraft to a quick stop. A-286 was selected because it provides good strength even though it is subjected to jet exhaust flames which reach temperatures of 600-700 F.

Source: Allegheny Ludlum Steel Corp.; hook used on Navy T2J jet trainers.

Castings cored with glass tubing

High purity 96% silica glass tubing is the basis of a unique method of precision forming tiny cores in high temperature metal castings. The glass tubing is fixed to the inside of a precision casting mold before pouring. After the metal has cooled, the glass tubing is readily leached by molten caustic without harm to the casting. The result: a core of precise measurements requiring no machining. The 96% silica glass was selected because it can withstand casting temperatures over 3000 F; is available in straight, curved or bent sections; has an extremely low coefficient of expansion; is available with an o.d. as small as 0.020 in.; and can be held to tolerances of ± 0.001 in. per in.

Source: Corhart Refractories Co. Inc., sub. of Corning Glass Works.

Tiny piece of platinum makes boat corrosion proof

One-third of an ounce of platinum, a small neoprene insulating blanket and a special electrical unit are said to be all that is required for cathodic protection of pleasure boats. Platinum was selected because of its exceptional corrosion resistance. (Although the system is not new—it is used on the new "Independence," the atomic sub "Triton," and many other large ships—this is the first time it has been used for small boats.)

Source: International Nickel Co.; system devised by Charles Engelhard, Inc.; used in "Platinode" boat built by Chris-Craft Corp.

Vinyl coating gives autos a leathery finish

Textured vinyl coatings are now being used to give automobile roofs a grained leather appearance. In addition to avoiding the production costs which would be involved if real leather or fabric were used, the vinyl coating is said to offer a surface that is highly resistant to cracking, peeling, fading, chipping, blistering and abrasion.

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp.; coating formulated by J. L. Armitage Co.; used on Chrysler autos.

Tantalum gradient furnace

Three tantalum strips spotwelded together in the form of an "H" are the basis of a small resistance furnace which provides a simple, compact means of obtaining a gradient between selected temperatures. Tantalum was selected because of its excellent heat resistance. One such furnace, used in crystal growing work, is constructed of a crosspiece 4 in. long, ½ in. wide and 0.005 in. thick, and legs 3 in. long, ½ in. wide and 0.01 in. thick. Thermocouples for temperature measurements are placed at various points along the crosspiece. Measurements can be taken at any temperature between room and 1650 F. Size of the "H" furnace can be modified to fit any

(continued on p 9)

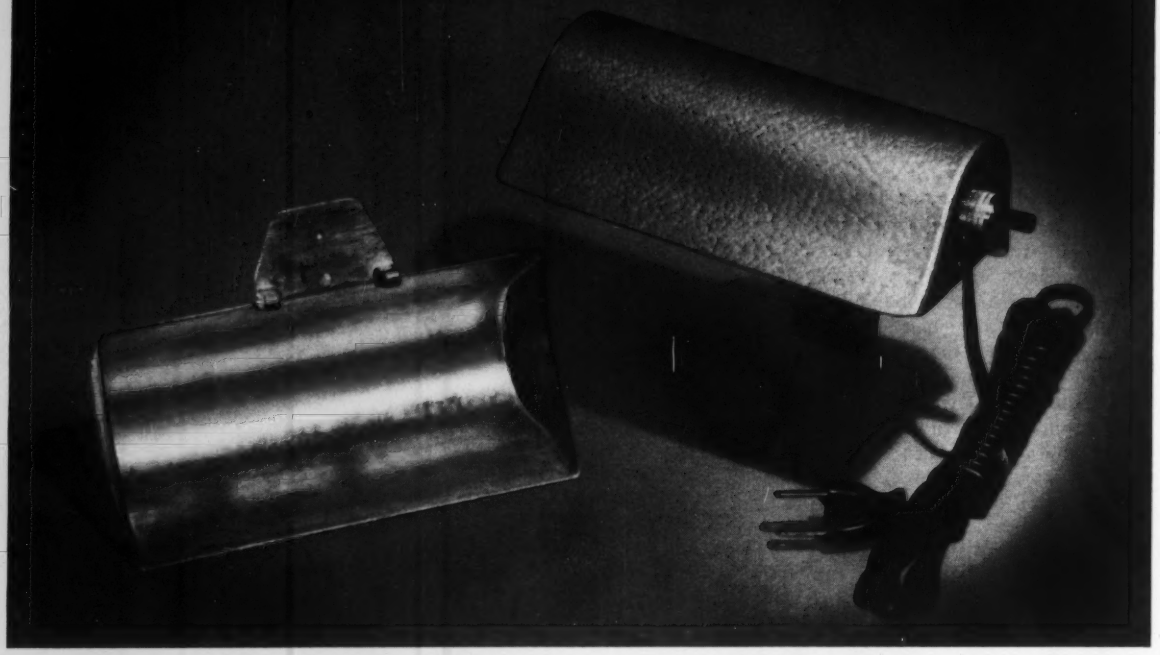
Briefs

Exploded "frogs" live longer, according to the New York Central Railroad. The frogs (steel inserts used where two rails intersect) are wrapped with a sheet explosive and detonated. Shock waves penetrate the steel and greatly increase hardness and wearing qualities.

Plastics laminates are being shot in an attempt to dramatize their high impact strength. In one such test, a 5/16-in. thick glass cloth-reinforced epoxy laminate was shot from a distance of 30 in. with a .38 calibre, 158 grain bullet having a velocity of 800 fps. The only result was a marking caused by lead in the cast bullet which was easily removed by solvent wiping.

Nickels minted yearly in the United States require 2,500,000 lb of metal. However, only 500,000 lb are nickel; the remaining 2,000,000 lb are copper.

IT'S LIGHTER THAN YOU THINK!



AND EASY TO ASSEMBLE WHEN DIE CAST WITH... ZAMAK

The shade for this new KLIP-LITE* music stand is made of a single thin-wall zinc die casting—for light weight and low-cost assembly. As thin as a stamping but with far greater rigidity, the contours could not be duplicated in sheet metal.

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*Made by WIESE MANUFACTURING COMPANY—Davenport, Iowa.

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application, and both the high and low temperature limits can be extended (tantalum can resist heat up to about 3630 F).

Source: National Bureau of Standards.

Nike motor guard molded of alkyd

Lower costs, ease of fabrication and improved appearance are the reasons given for the selection of molded alkyd for motor guards used in Nike missiles. Original plans called for the part to be fabricated from glass-reinforced plastics. However, the finished cost of the molded alkyd part turned out to be less than the cost of the glass-reinforced plastics raw material. In addition, the alkyd part satisfies all requirements of strength, density and heat resistance.

Source: Plastics and Coal Chemicals Div., Allied Chemical Corp.; part used by AiResearch Mfg. Div., Barrett Corp.; molded by Maas-Rowe Carillons.

Aluminum fishing boats

Aluminum has replaced steel in small ocean-going fishing boats. The 36-ft crafts, which work from a "mother" ship, weigh 3000 lb less than the previously used steel boats and are expected to substantially cut operating costs. In addition, maintenance costs are expected to be lower as a result of aluminum's high resistance to sea water corrosion. Boat hulls are formed of alloy 5052 sheet and plate. Supporting ribs are extrusions. The boats are welded.

Source: Aluminum Co. of America; boats designed and fabricated by RTC Shipbuilding Co.; used by Fish Products Co.

Molded nylon coupler outwears brass

The switch from brass to molded nylon has resulted in a hose coupler which is said to outwear previous models by four-to-one. Molded nylon was specified because of its exceptional toughness, light weight, resistance to rust and the ease with which it turns over metal threads of faucets and other metal connectors. In addition, it is said to remain water-tight indefinitely.

Source: E. I. du Pont de Nemours & Co.; coupler manufactured by W. D. Allen Mfg. Co.

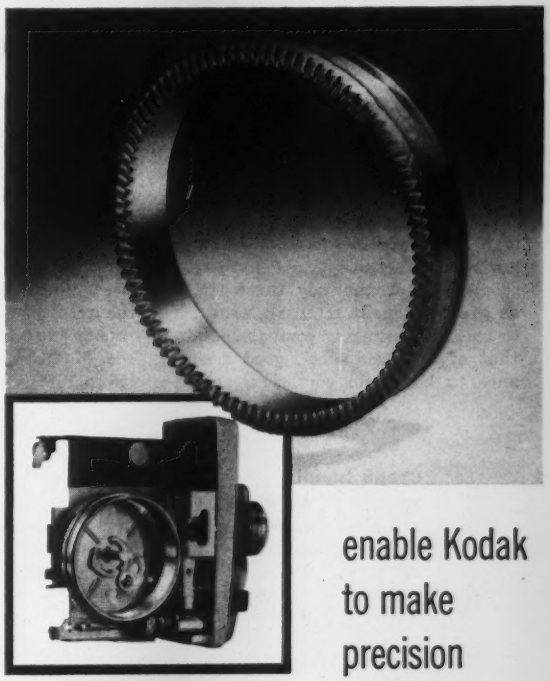
Cost of clutch parts cut by extruded steel bars

The use of hot extruded-cold drawn steel bars has cut production costs by almost one-third in the manufacture of clutch pawls previously machined from rectangular bar stock. Although the extruded-to-shape bars cost about 20¢ more per part, they cut machining costs from $7.25 per part to $2.65 per part for a saving of $4.60. Main operations eliminated are profile and plain milling to produce the required contour. Time saved amounts to 25 min for machining and 2 hr, 20 min for machine set-up.

Source: Jones & Laughlin Steel Corp.; part used by Jones & Lamson Machine Corp.

(more Materials at Work on next page)

ECONOMIES SUCH AS THIS...



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Five case histories show how . . .

Iron castings simplify design, cut costs

MATERIALS AT WORK

Edited by Walter Lubars

Gray and ductile iron castings offer many advantages as a basic engineering material. These advantages include: low cost, excellent machinability, excellent damping capacity, self-lubricating properties, high resistance to wear and seizure, low notch sensitivity, compressive strength approximately three times as great as tensile strength, response to heat treatment comparable to that of eutectoid steel, good resistance to heat and corrosion, and a controllable modulus that minimizes distortion during heating.

The accompanying photographs (submitted by the Gray Iron Founders' Society) show five cases where cast iron replaced an earlier material. The captions outline the design or materials selection problem faced by the engineer, how it was solved, and the resulting benefits. (For a comprehensive discussion of cast iron, see MATERIALS AND METHODS, Oct '56, p 131.)

Crank handle *Problem:* To improve and simplify a crank handle used on an accounting machine.

Solution: One shell molded gray iron casting replaced these eight parts previously used: a steel forging, two screw machine parts, a die casting, and a spur gear, all held together by three taper pins. Shell molding was chosen to insure accurately formed gear teeth and a hole with a 0.515-0.510-in. dia as cast. Change eliminated all machining: the only operations necessary after casting are polishing the handle, wire brushing the gear teeth, and cadmium plating the crank gear.

Result: Costs cut by 78%, appearance greatly improved, and weight reduced substantially.

Bennett-Ireland, Inc.

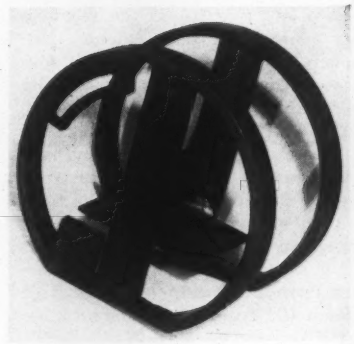
Cooper Bessemer Corp.

Exhaust manifold *Problem:* To avoid warping and scaling, and hence frequent failure, of exhaust manifolds used to handle gases at temperatures up to 900-1000 F.

Solution: Switch from a continuous weldment to class 60-40-10 ductile iron castings. The new manifold consists of several individual machined castings to allow for expansion.

Results: Elimination of failure as a result of ductile iron's excellent scale resistance and elevated temperature strength.

BEFORE . . . **. . . AFTER**



Virginia Foundry Co.

Type cylinder *Problem:* To simplify and reduce cost of a type cylinder for an automatic imprint press.

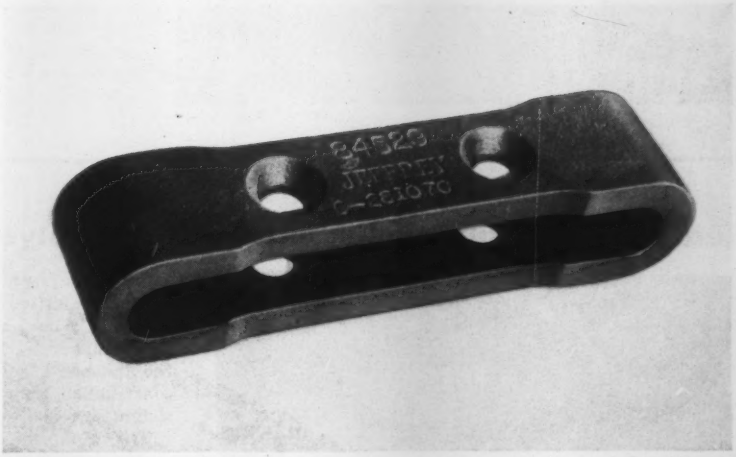
Solution: A one-piece gray iron casting was substituted for a multiple-part weldment which required complicated machining, welding and handling operations.

Results: Cost reduction of 87%, product improvement (smoother operation and longer life due to greater wear resistance), and simplified manufacture (better machinability and elimination of welding and seven other operations).

Block link *Problem:* To "find a better way" of making a block link for a heavy conveyor chain when forming equipment and dies costing $42,000 had to be replaced.

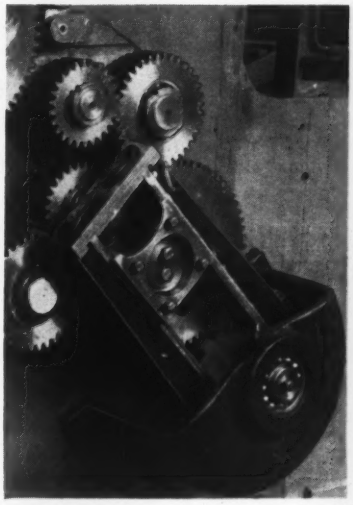
Solution: A ductile iron casting replaced an SAE 1020 steel weldment.

Results: Costs reduced by about 61%; average tensile strength of casting is about 15,000 psi greater than that of welded link (49,000 psi for the casting, 33,700 psi for weldment); increased wear life of chain as a result of ductile iron's better abrasion and corrosion resistance; and elimination of all other operations such as countersinking holes, welding, stamping, etc.



Jeffrey Mfg. Co.

BEFORE . . . **. . . AFTER**

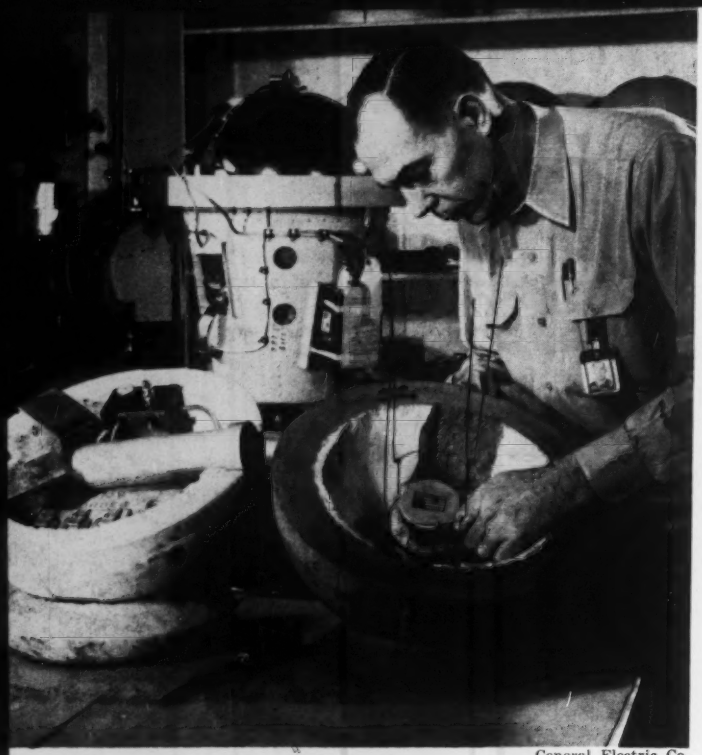


S & S Corrugated Paper Machinery Co.

Rocker arm *Problem:* To simplify and reduce cost of a rocker arm for a crank mechanism used in a paper machine.

Solution: Replacement of a 9-piece steel fabrication with a single gray iron casting.

Results: Complete assembly reduced to three parts, weight reduced by 48% and cost cut by 74%. In addition, performance of machine was raised and quality of work improved.



General Electric Co.

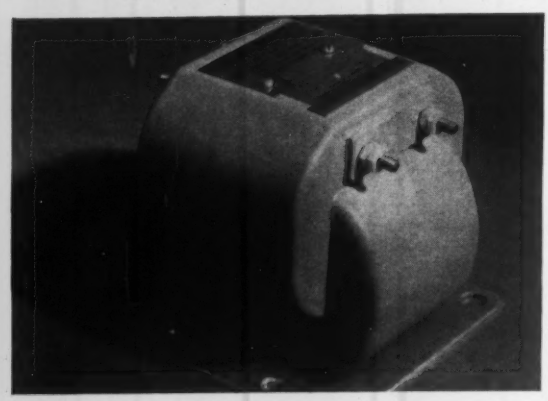
Urethane foam package protects recording instruments in missile

A spherical instrument package made of urethane foam is performing a key function in the recovery of recorded scientific data from outer space.

The urethane sphere, which is carried in the nose cone of the Atlas missile, is used to protect recording instruments from vibration and shock from the time of launching to the time the cone is ejected and returned to earth. According to Du Pont, urethane foam was selected because it withstands impacts up to 45,000 times greater than that caused by the force of gravity, yet is light enough to float. (One Atlas instrument package was found floating and intact after two months.)

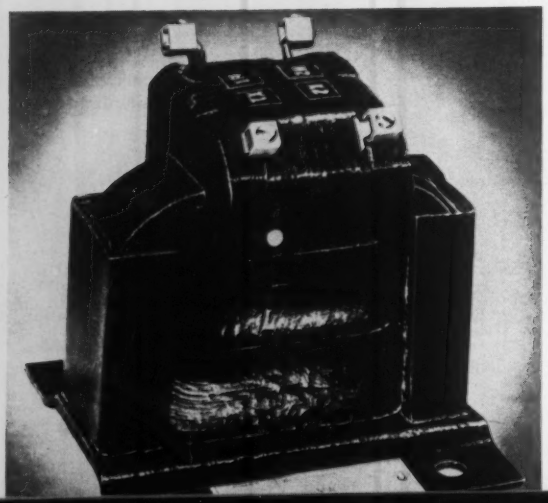
The package consists of an outer shell of high density urethane foam (20 lb per cu ft) and an inner core of relatively low density foam (6 lb per cu ft). The sphere is constructed by first molding the outer shell in halves (see photo at left). The heaviest part of the equipment is then embedded in a separate shaft and the softer foam is poured into the cavity around the other parts of the equipment. The two halves are cemented together with a urethane-based adhesive.

Redesigned transformer uses molded polyester



New

Old



Glass-reinforced polyester structural members and a polyester elastomer housing play important roles in the design of a new, molded voltage transformer. According to Westinghouse Electric Corp., the new transformer is the first of its type to be designed specifically for molded construction and has replaced an older model with a weight and size reduction of about 40%.

The transformer is built up around a split rectangular core consisting of two C-type half-cores. The coils are wound onto a molded reinforced polyester bobbin which fits over the top of the core. The polyester bobbin is the key to the reduction in size and weight of the transformer: it is constructed so that both primary and secondary coils can be wound side by side onto the same part. To separate the two coils, an insulating partition is integrally molded around the circumference (see photo on p 176).

A channel-shaped part, also molded of reinforced polyester, serves as both terminal block and protective cover

(continued on p 176)

MORE MATERIALS AT WORK

Hard surfacing protects dust collector 176

Precision-built tank 178

Liquid sealant eases bearing replacement 180

Stainless well filters replace carbon steel 182

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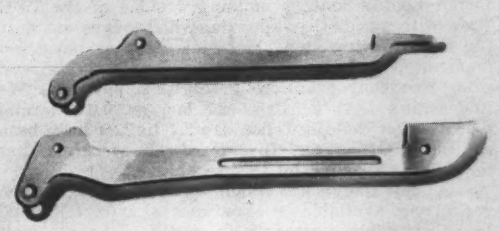
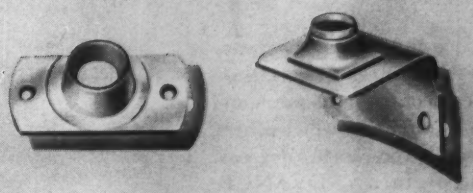


FASTENERS:

- Improved drawing qualities
- Reduced rejects
- Lowered production costs
- Cut quality control costs



COLD ROLLED SPRING STEEL MET THESE RIGID SPECIFICATIONS:

ANALYSIS: AISI 1055 • **ROCKWELL:** B 85-95
MICROSTRUCTURE: Uniform grain structure and carbide distribution
GAUGE TOLERANCE: ± .0003" including crown
WIDTH TOLERANCE: ± .005"
SIZE: 2" x .0384"
FINISH: No. 2 • **EDGE:** No. 3
COIL SIZES: 200/250 lbs. per in. width

ANALYSIS: AISI 1045 • **ROCKWELL:** B 72 max. Deep drawing qualities
MICROSTRUCTURE: Well rounded and uniformly distributed carbides in a ferrite matrix
GAUGE TOLERANCE: ± .001"
WIDTH TOLERANCE: ± .005"
SIZE: 1½" x .020"
FINISH: No. 2 • **EDGE:** No. 3
COIL SIZES: 200/250 lbs. per in. width

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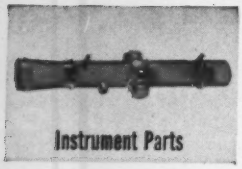
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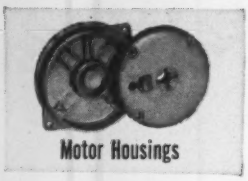
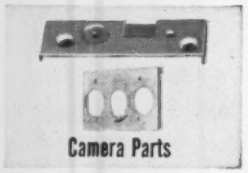

Motor Housings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Foamed Teflon?

To the Editor:

The letter from Dr. W. P. Murphy, Medical Development Corp., which appeared on p 7, Nov '58, concerned foaming and vacuum forming of Teflon fluorocarbon resins, and we thought that the following additional information would be of interest.

Although the TFE resins have not been foamed, they have been molded into a spongy or "leathery" form. This is done by molding a blend of the TFE resin with some other material which burns out during the sintering step. Materials such as powdered ammonium carbonate, acrylic resin, polystyrene, and even woodflour work well for this purpose. We understand that densities as low as 0.6 (normal densities for molded Teflon are 2.1 to 2.2) have been attained. Of course, the closed-cell structure has never been feasible by this technique.

A new polymer, Teflon 100X perfluorocarbon resin, now available in experimental quantities and to be available commercially in late '59, is a melt processible resin, and naturally this means that it can be fabricated by the same techniques used for the other thermoplastics. I have not learned of any attempts to foam this resin, but the relative ease of processing of Teflon 100X indicates that it should be eminently feasible. In regard to Dr. Murphy's other question, vacuum forming of extruded sheet of Teflon 100X has been successfully done in our laboratories.

L. A. Ferris
Applications Technologist
Polychemicals Dept.
E. I. du Pont de Nemours & Co., Inc.
Wilmington, Del.

Amine epoxy coatings

To the Editor:

In reference to your fine compilation of the properties of organic coatings, *1958-59 Materials Selector*, p 267-269, I should like to call attention to the following:

1. Epoxies are rated as having poor adhesion. It is true that this is a characteristic of these coatings. But, amine epoxies, converter type, are the kind we use at this plant and we have successfully applied this material for the past two years over coatings which were formulated by the use of linseed, soya, castor, marine drying oils and, to a limited extent, over asphaltic-based materials. We do this by using a tie coat, i.e., a specially prepared intermediary coating which locks out the ketones and prevents solvent entrapment and resultant deterioration.

This intermediary coating is formulated to act as a rust inhibitor over broken areas or areas where rust has been activated. It contains about 19%

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Going Plastisols One Better

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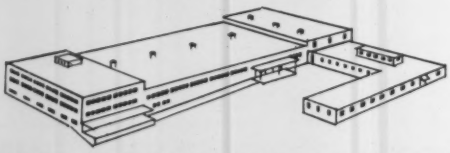

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strontium chromate. Its solvents are very selective and the material has a flow equal to the best. Lifting has never occurred except in a few instances where adhesion of the old coating was not realized (grease, oil, etc., on original surface). This intermediate coating is an amine epoxy wherein a converter is used, and gives about 2 mils thickness to the coat (400 sq ft dry film thickness spread).

2. Color retention of epoxies is rated as good. In most cases this is so. However, where nitric acid fumes are involved in conjunction with certain heavy humid air the material loses its color (medium gray) in a matter of a few weeks. It turns a brackish green.

3. A coating which you might list is the epoxy-tar-modified phenolic or Thiokol copolymer. Excluding exposure to ketones, the coating is practically inert.

ROBERT F. SNYDER
Paint Foreman
National Lead Co.
Cincinnati, Ohio

Hafnium for reactors

To the Editor:

In the *1958-59 Materials Selector*, p 103, it is incorrectly stated that no applications have been developed for hafnium. Hafnium is in very short supply today because of its superior properties as a corrosion resistant neutron absorber, making it almost unique as a material of construction for control rods in nuclear reactors. Hafnium is used as the material of construction for the control rods in the nuclear reactors aboard our country's submarines, and in the control rods of the Shippingport reactor; and would be used in a good many other reactor control systems if it were available.

Its availability is limited by the demand for zirconium, inasmuch as it is produced as a byproduct of zirconium production. Although zirconium and hafnium have almost identical chemical properties, their nuclear properties are quite dissimilar and the two materials must be separated before either is of use for nuclear reactors.

GORDON KIDDOO
Vice President
Columbia-National Corp.
Cambridge, Mass.

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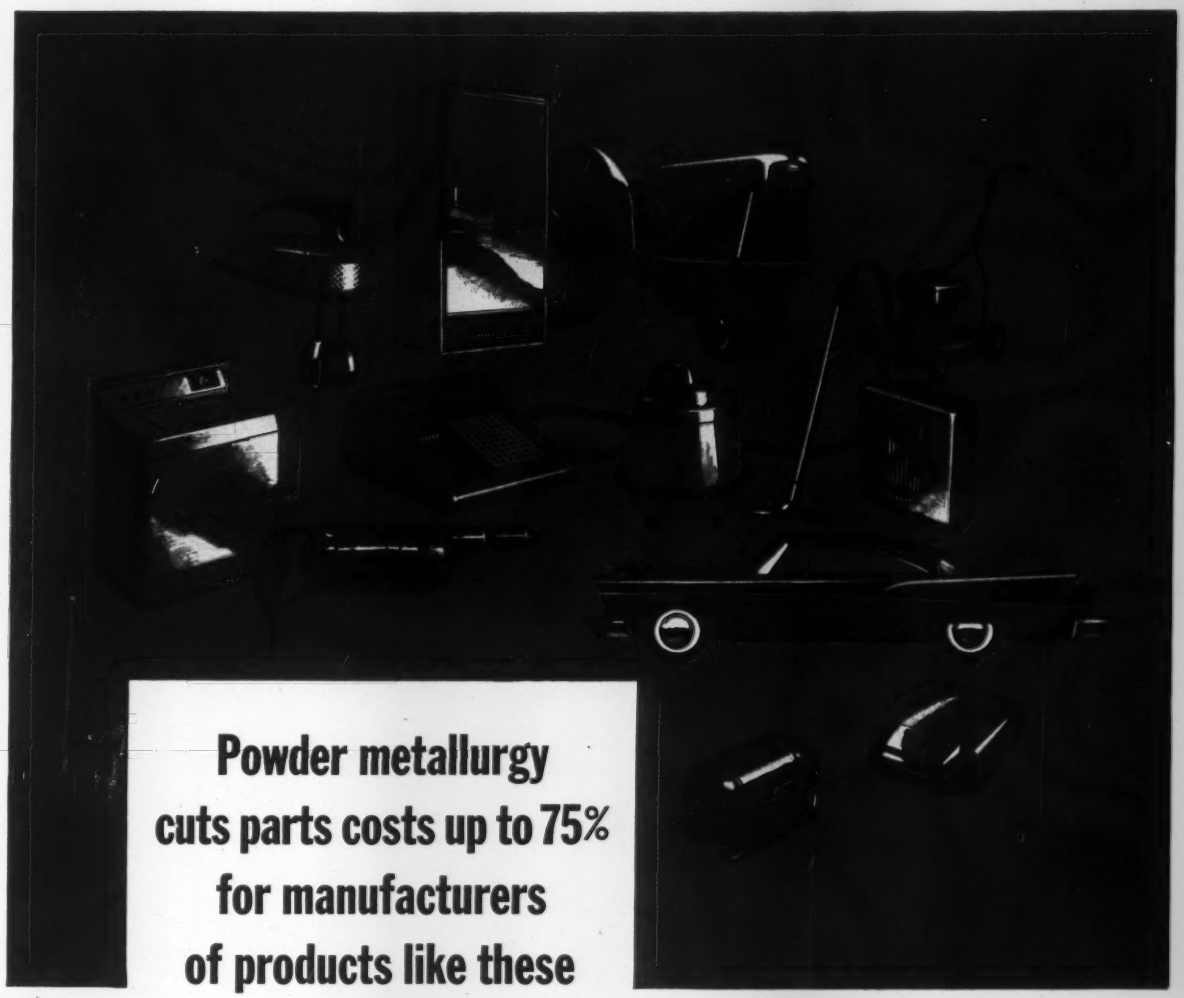
Each month $10 will be paid for the best letter written to an author, an editor, or addressed to *Letters to the Editor*. We reserve the right to withhold awards.



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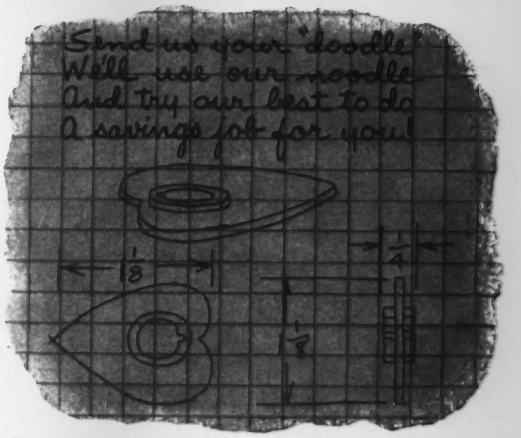

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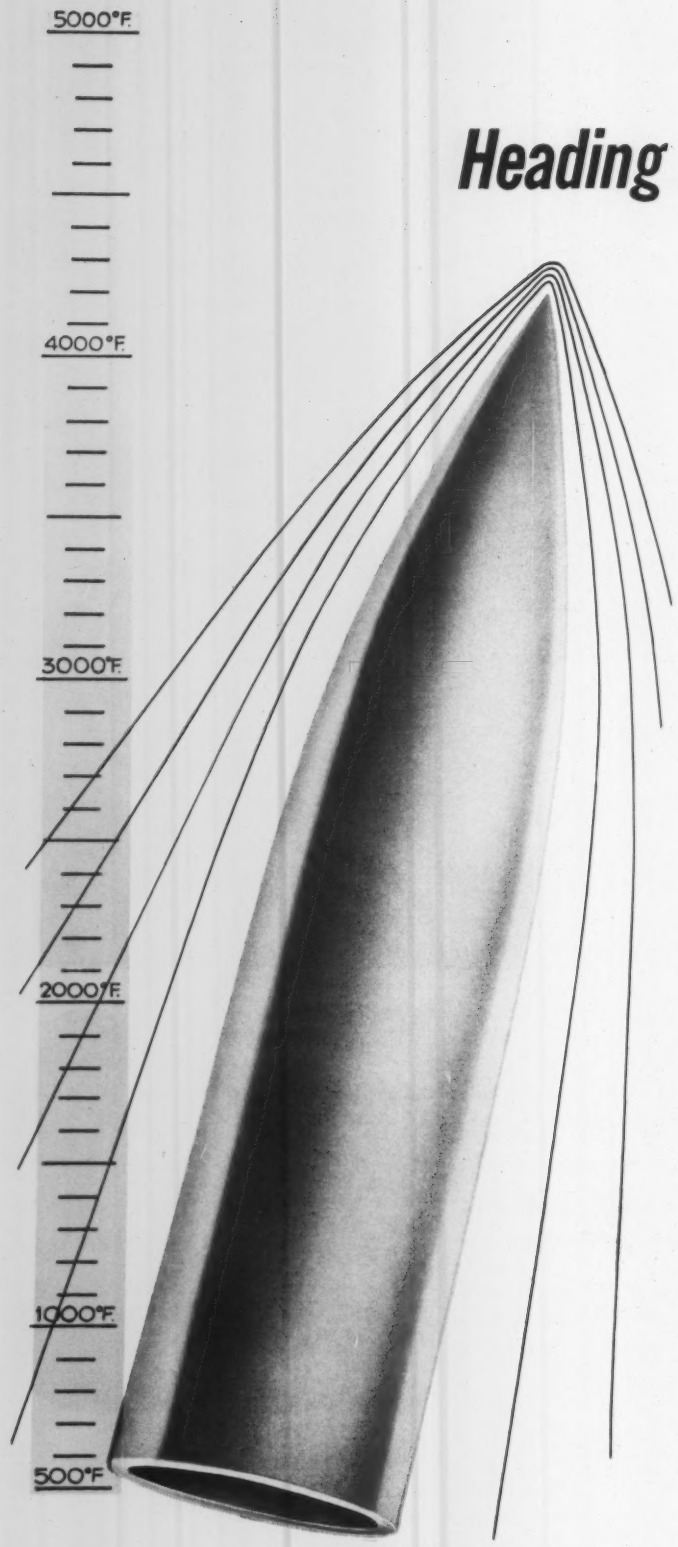

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Electrical Resistivity	High Temperature Conductor
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Two Grain Types	Hard Dense Grains
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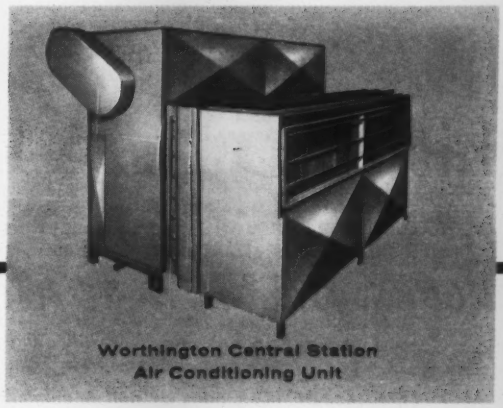
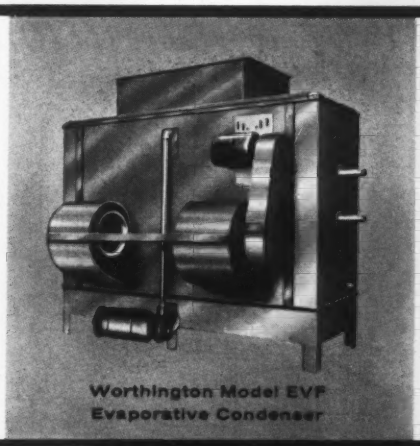


Worthington Central Station
Air Conditioning Unit



Worthington Model EVF
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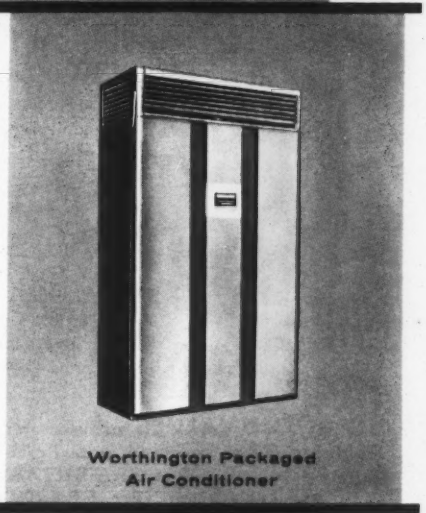

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Wolverine supplies Worthington with different types of copper alloy tubing. There is, for example, prime surface tubing in both straight length form and in fabricated hairpin bends for use in heater coils and evaporators, etc.

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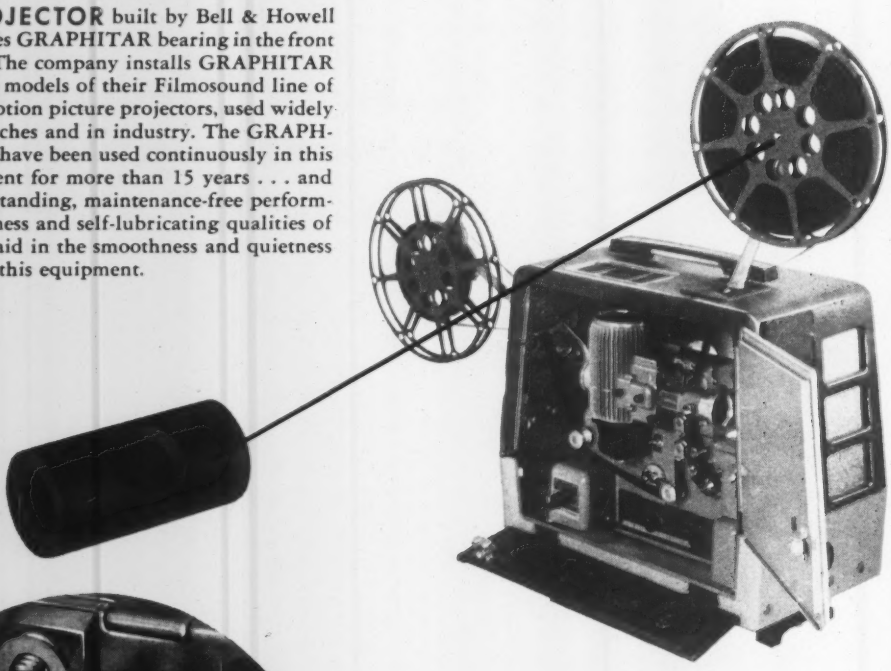
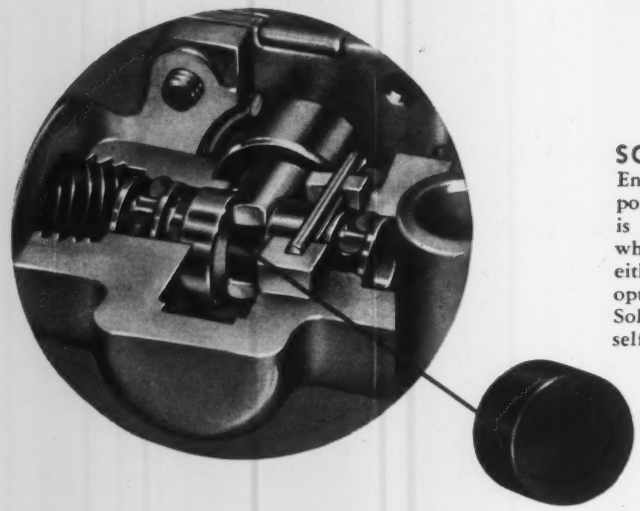
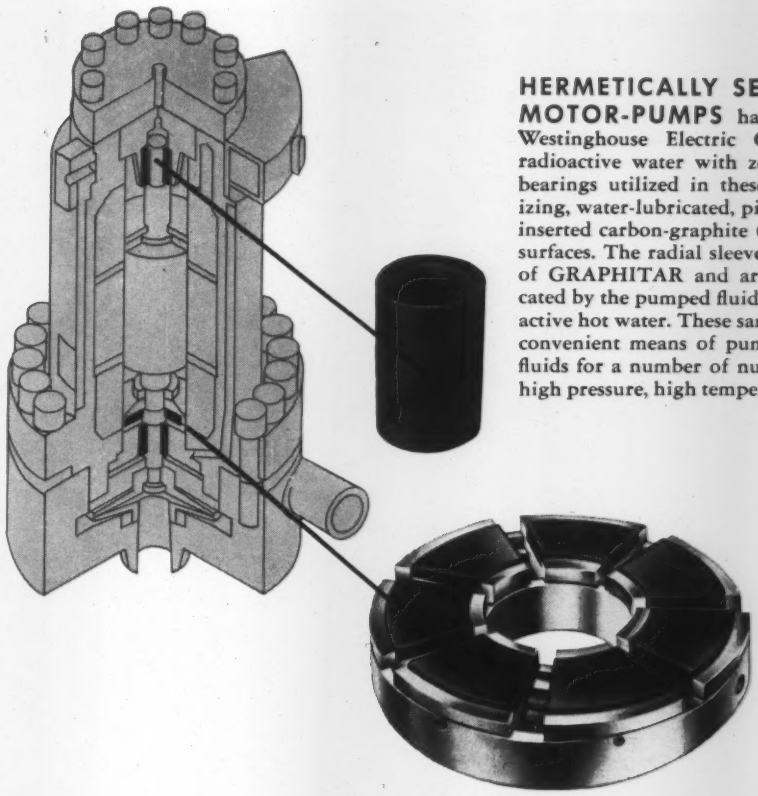




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

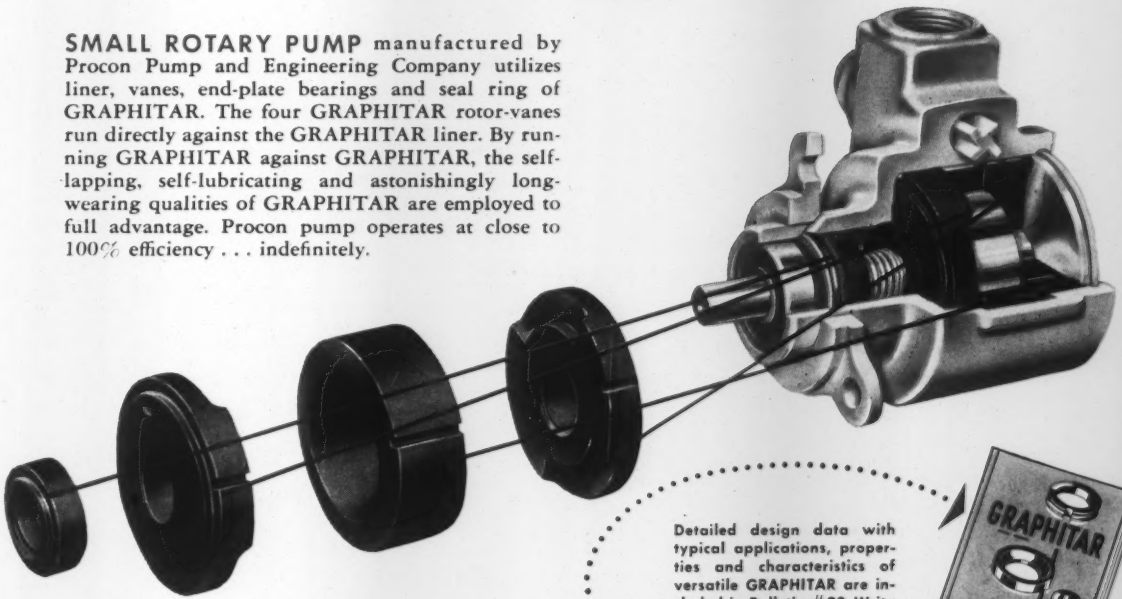
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

Lenses designed with **Plexiglas** in mind

Problem. Design of a magnifying lens system for 35mm slide viewer*.

Requirements. Five-times enlargement of slide picture with clarity, sharpness and freedom from distortion. Lens system to be resistant to impact if viewer is dropped. Viewer to be priced within range of single-lens units.

Solution. Dual lens system, with lenses molded of optical grade PLEXIGLAS® acrylic plastic. Use of PLEXIGLAS resulted in lenses that give excellent performance and are highly resistant to breakage. Because lenses could be *molded* precisely to fine tolerances, considerable production cost savings were achieved through elimination of lengthy grinding and polishing operations required for glass lenses.

*"Opta-Vue", by Optics Mfg. Corp., Philadelphia 34, Pa.

Examples of fine quality molded parts made of PLEXIGLAS, *in many fields of use, are shown in our full color brochure,* "PLEXIGLAS *for Molded Parts". We will be pleased to send you a copy.*

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill*
Crystal Glass & Plastics, Ltd., Toronto

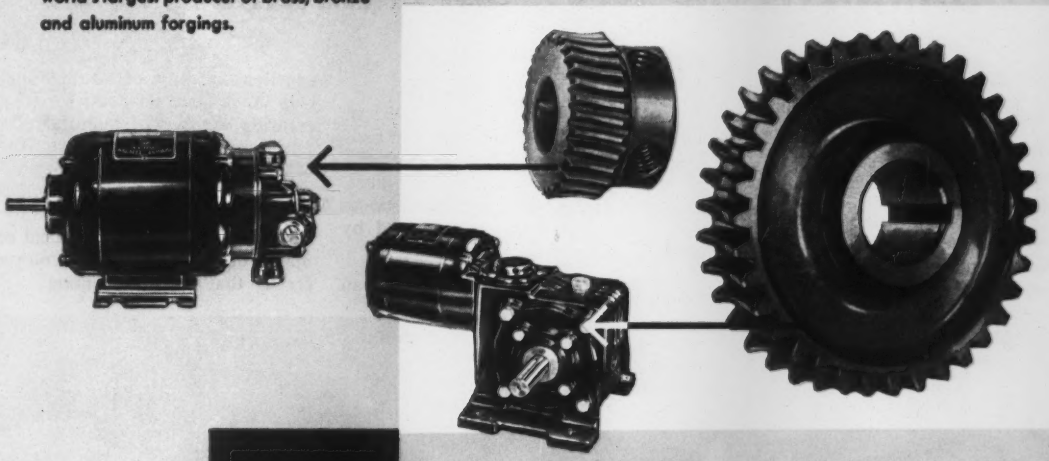
For more information, turn to Reader Service card, circle No. 503

MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

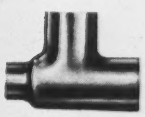
For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

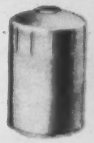
can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the *only* fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the *one* best way.

Write today for complete catalogs on any of these products.



FORMED COPPER TUBE

PLASTICS INJECTION MOLDING



COLD-PREST IMPACT EXTRUSIONS

SCREW MACHINE PRODUCTS

POWDER METAL PARTS

RED BRASS CASTINGS

Also producers of: Super Cutting Rod Tip Brass Rod • Aluminum Extrusions Aluminum Sheet, Coil and Strip • Plastic Pipe and Fittings • Copper Tube and Solder Type Fittings •

MUELLER BRASS CO. PORT HURON 21, MICHIGAN

362

For more information, turn to Reader Service card, circle No. 410

DOW **NEW PLASTICS** *inspire new product designs*

The news columns have been filled recently with rapid-fire developments in thermoplastic materials . . . materials that hold promise for the improvement of hundreds of products, both old and new. As these stories break, you'll notice a high percentage of them featuring a Dow material. Take Zerlon* 150. A few weeks ago Dow introduced this weather resistant, optically clear plastic with an exciting new range of cost-saving properties. Several other news-makers in the complete Dow line are discussed on these pages.

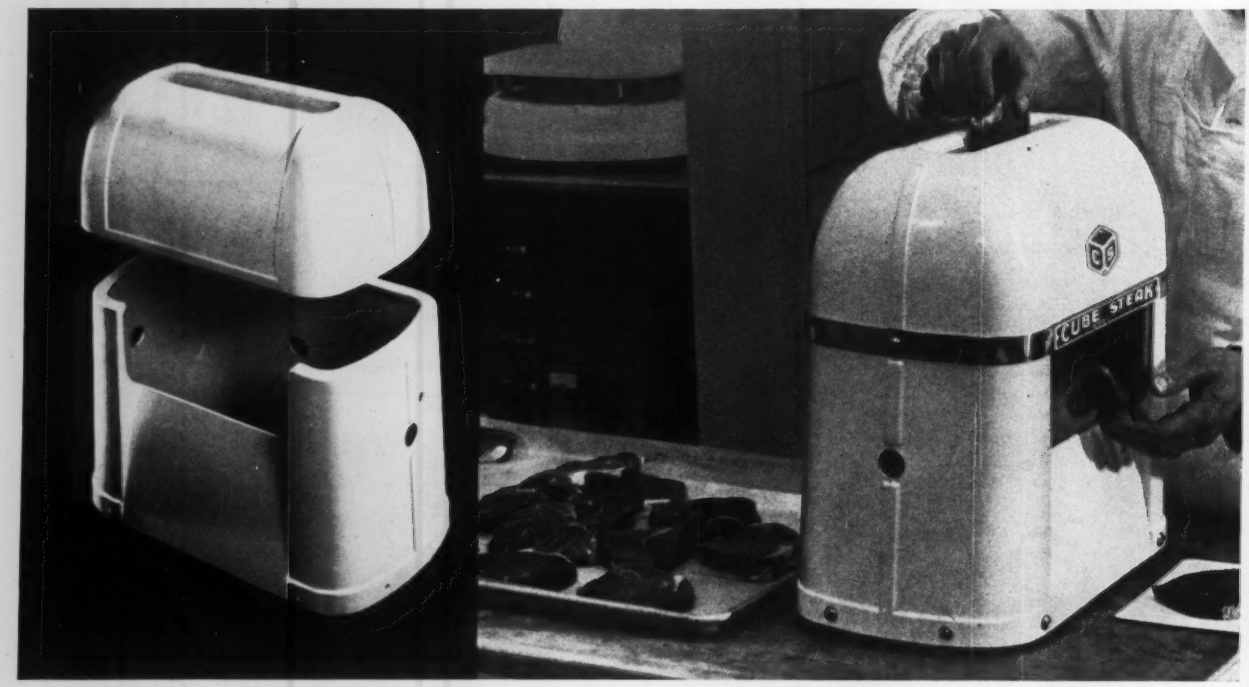
*Trademark

"AGELESS" STYRON 480 GIVEN LIFETIME GUARANTEE IN NEW SUPERMARKET TOOL

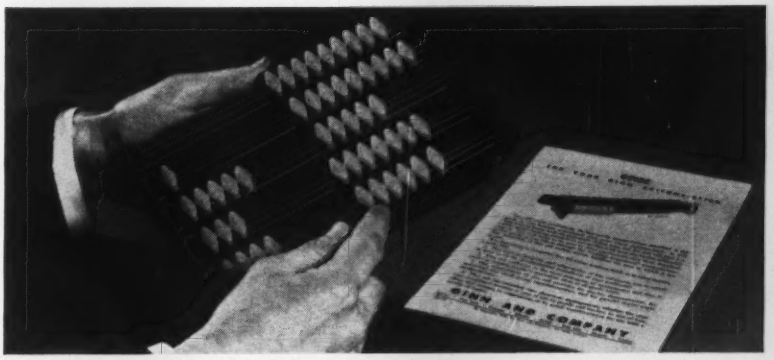
The housing of this new Cube Steak Tenderator is guaranteed for the life of the machine. This is a generous guarantee to make on equipment in rough and tumble supermarket service, but the manufacturer isn't worried . . . he knows the housing is made of Styron® 480. This versatile thermoplastic was chosen because it's durable and highly resistant to meat juices, has super high impact strength, an easy-to-clean surface.

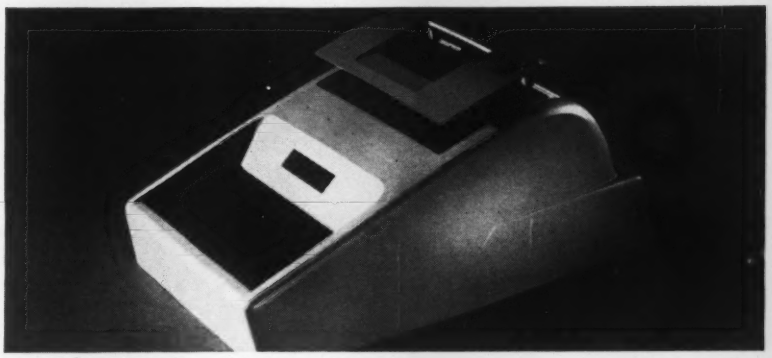
The excellent aging characteristics of Styron 480 were also an important consideration. In fact, the lifetime guarantee could not have been made without them. Fabrication was simplified and production costs substantially reduced by switching to plastic.

The housing made of Styron 480 is an excellent example of how Dow plastics help make good products better. An increasing number of manufacturers are selecting from the extensive Dow line of eight basic thermoplastics and dozens of specialized formulations. And you get extras from Dow you can't buy on a cost-per-pound basis: technical service, marketing assistance and a color styling service that's second to none.



THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN





Ready for the sales countdown . . .

with this abacus made of Styron 475

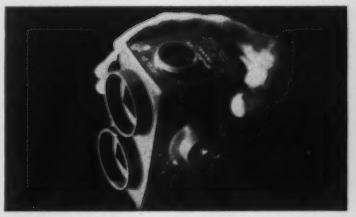
A prominent publishing house markets this attractive, highly useful educational tool. It's made of polyethylene and Styron 475, a high impact Dow plastic with excellent dimensional stability, design flexibility and moldability to spare. This abacus was developed for the publisher by a custom molder who offers integrated design, engineering and production services. It's another example of how creative engineering utilizes the many benefits of Dow plastics in new product designs.

. . . and this adding machine housing molded of Styron 440

Outstanding impact strength, design versatility and a wide range of colors make Styron 440 an obvious choice for this application. The housing is easy to keep clean and its high resistance to heat prevents distortion when the machine is displayed in direct sunlight. Styron 440 also eliminated the extra fabrication and finishing operations that were necessary with the material previously used in the housing. The surface is smooth and polished when removed from the mold.

4 MORE PRODUCTS

fashioned from America's first family of thermoplastics



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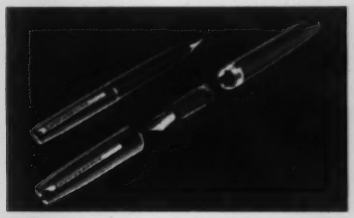

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FOR MORE INFORMATION about the versatile Dow plastics and the product designs discussed on these two pages, write to us today. THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1510CD3.

Industrial Molding Materials • Packaging Materials • Paint and Coating Materials • Building Products

DOW

For more information, turn to Reader Service card, circle No. 468

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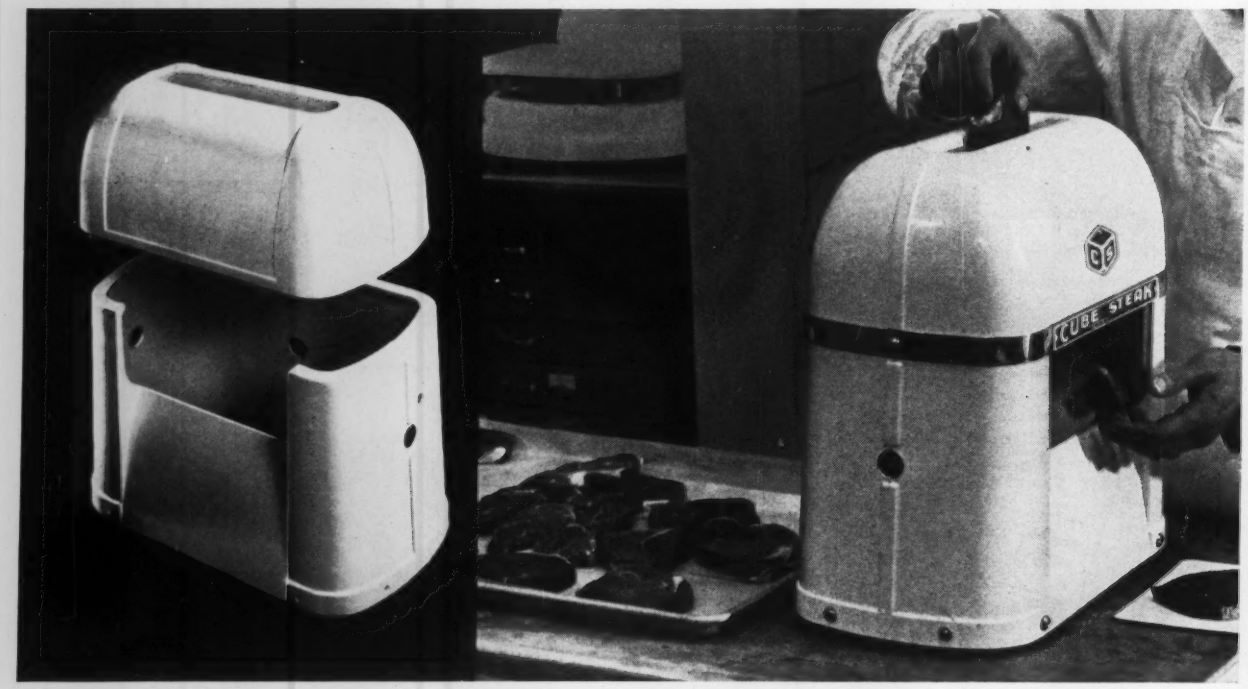
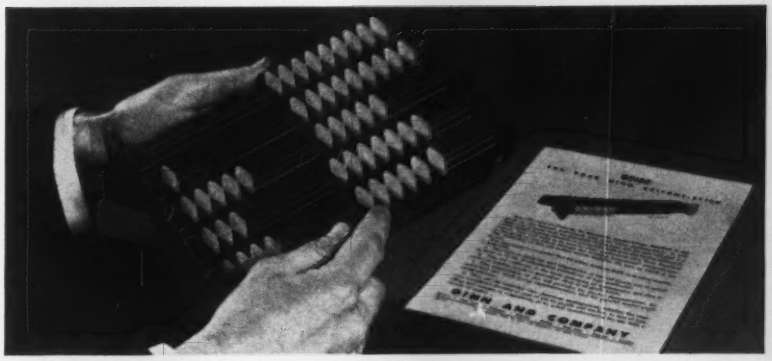
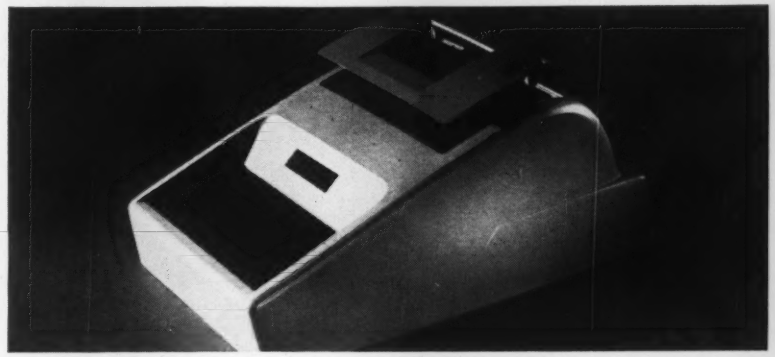


THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN





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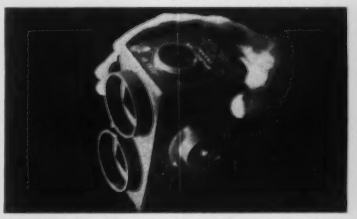

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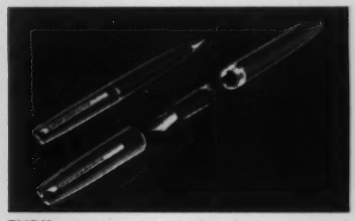

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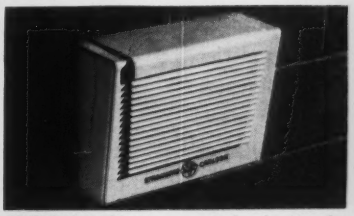

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Industrial Molding Materials • Packaging Materials • Paint and Coating Materials • Building Products

DOW

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Looking for high impact and flexural strength *without premium price?* You can now get these qualities with Thermaflow 105, a new reinforced polyester molding compound priced about 20% under other high-strength compounds. Its corrosion resistance and smooth surface finish are exceptional.

There's no end to the products into which you can design new properties and economies with this material. Consider it not only for parts you now make of die-cast and fabricated metal, but also for pieces you may have been designing for other structural plastics. Write today for complete data and samples.

TYPICAL DESIGN DATA

	ASTM Bar	⅛" Random cut specimen
IMPACT STRENGTH ft.-lb./in. (Izod, notch)	12.0	4.5
FLEXURAL STRENGTH	20,000	16,000
HEAT DISTORTION	>450°F	>450°F

CHEMICALS DIVISION
ATLAS POWDER COMPANY
WILMINGTON 99, DELAWARE
In Canada: Atlas Powder Company, Canada, Ltd.
Brantford, Ontario, Canada

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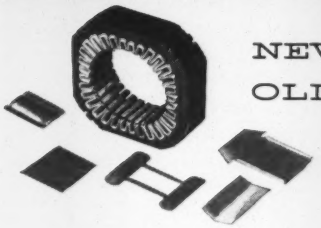
MOISTURE RESISTANCE



NEW SPAULDING 33 INSULATION LICKS AN OLD PROBLEM IN ELECTRICAL MOTORS

Special Properties:
Dielectric Strength—110 volts/mil after 4 hours total immersion in water.

New Spaulding 33 is a superior electrical insulation for motors operating under conditions of high humidity or moisture collection, such as fan, air-conditioner or "splash proof" installations.

Spaulding 33 maintains high dielectric strength even when completely immersed in water due to a unique new treatment of its 100% rag paper base which prevents moisture absorption after edges have been cut.

We will fabricate **Spaulding 33** to your specifications. It is also available in sheets, rolls and strips.

Contact Spaulding for complete information

Our 5 Plants and 28 Branch Sales Offices serve all industries
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SPAULDING FIBRE COMPANY, INC.

306 WHEELER STREET, TONAWANDA, NEW YORK

For more information, turn to Reader Service card, circle No. 446

Formability—In days of old, when knights were bold, they also were smart. When their very lives depended on a tool or a weapon, they made sure it was made from steel. It could be a great claymore, hefty enough to behead a horse; a bright suit of armor that would turn the Saracen's arrow; or an ornamental castle gate, strongly made to frustrate the assassin.

They wanted steel because it was strong. They could *use* it because it was formable. Truly, there is no economical metal in all the world that can approach steel's combination of strength and formability.

With the near-magic of heat treating, you can soften steel and form it, then harden it to make it strong, then temper it to make it tough. Or form it cold. Use bending, flanging, deep drawing, spinning, cold heading, die drawing, rolling, wiper forming, draw rolling, stretch forming or bumping. In fact, it's hard to imagine any forming operation that cannot be performed on steel.

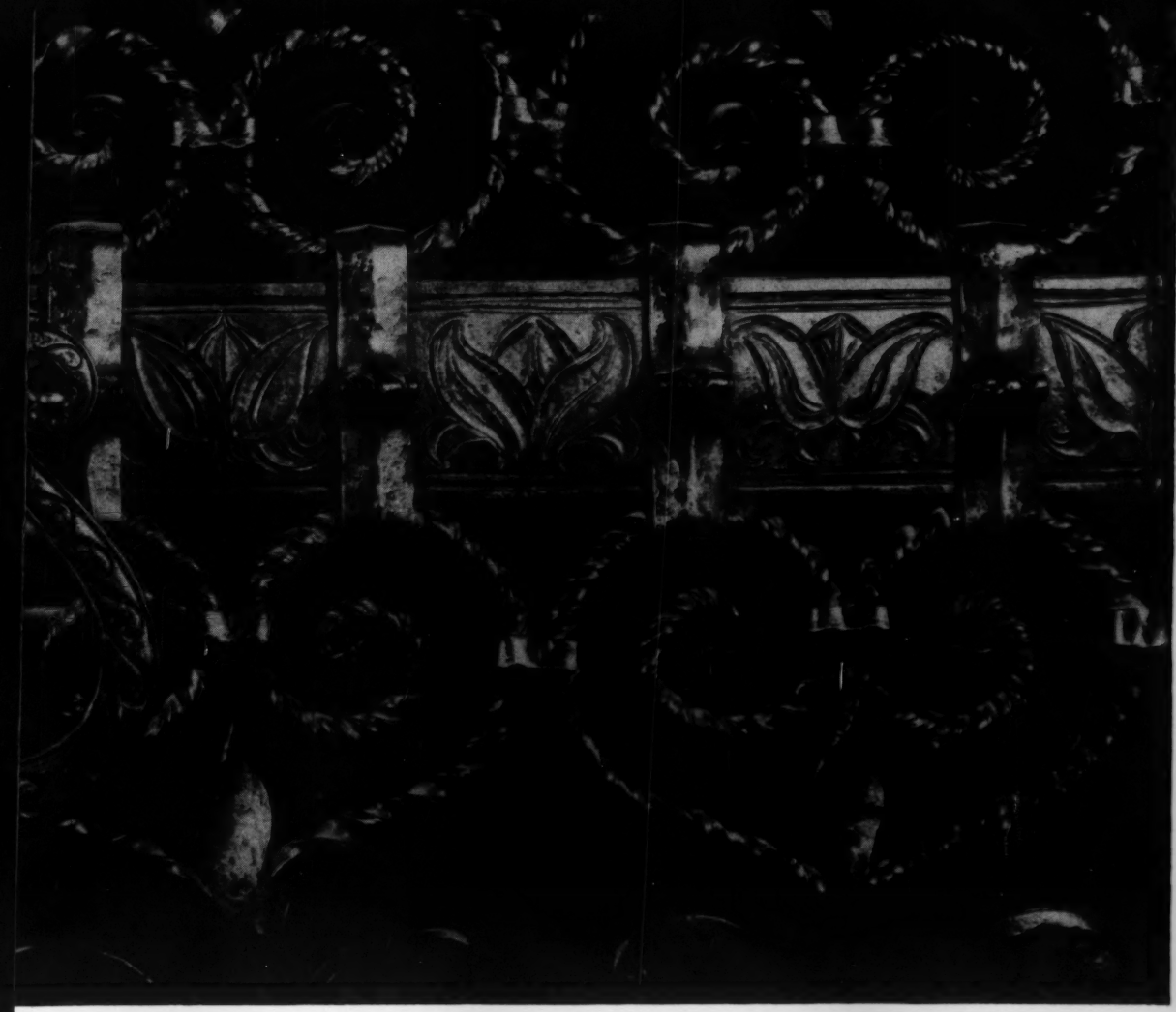
Fortunately, there are hundreds of different kinds of steel; and they all act differently in the fabricating shop. Everything you do to steel alters its *forming* properties, and every forming operation alters its physical properties.

The aim of the product designer is to find a steel that can be properly formed, that has the right strength, toughness, corrosion resistance, weldability or other characteristics required . . . at the most favorable cost. If you have a design problem and the comptroller is looking over your shoulder, take hope from this idea: there is one "best" steel for any design application. You can be sure of finding it among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless Steels.

If you need help in making your selection, ask a company that has produced well over a billion tons of steel, and has spent hundreds of millions of dollars to learn more about this most versatile of man's metals. Of course that means United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel



STEELS FOR DESIGN

Lower Left—Problem: Build a power shovel dipper stick with greater strength and shock resistance. Solution: Bucyrus-Erie Company designed a tubular stick made from USS "T-1" Constructional Alloy Steel. Payoff: The "T-1" Steel plates were easily cold-formed into a tube and butt welded. The tubular design and stronger steel assured great strength and shock resistance, and easy fabrication.

Lower Middle—Problem: Produce strong, heat resistant, corrosion resistant jet engine rings—*economically*. Solution: Alloy Manufacturing Company carefully selected a grade of USS Stainless Steel. Payoff: The rings resist heat and corrosion and they are economically roll-formed because the Stainless Steel is formed on "carbon steel rated" equipment.

Lower Right—Problem: Design a pressure tank that is just as strong but lighter than conventional carbon steel tanks. Solution: Manufacturer selected USS MAN-TEN High Strength Steel. Payoff: MAN-TEN's greater strength (50% higher yield point than carbon steel) permitted design of a thinner-walled tank that is 24% lighter. And because MAN-TEN is highly formable, the tank is economically produced by cold press forming of circular blanks into seamless shells, 29″ in diameter and 24″ deep.

USS, "T-1" and Man-Ten are registered trademarks

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels

Allegheny Ludlum knows more about stainless than anybody . . . and puts it in print for you

Allegheny Ludlum *should* know more about stainless than anybody: they've been the leading producer of all forms for more than 40 years. And the industry's only that old.

Today, A-L produces more different sizes, shapes, finishes and alloys of stainless than any other company. Backing up its quality products are research and development facilities with people second to none.

With know-how and experience gained over the years, Allegheny Ludlum keeps little of it secret: it offers the most complete selection of literature available anywhere.

Literature, designed to help you learn more about Allegheny Stainless and how it can improve your product, is just one help offered by Allegheny Ludlum. You also get the best assistance from trained salesmen and technicians, ready to help you on your specific problem.

All this service is available through your Allegheny sales engineer. Call him today. Or, as a starter, write for the publication list describing the over 150 technical pieces made to assist you.

Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa. Address: Dept. MM-15.

WSW 7133

ALLEGHENY LUDLUM

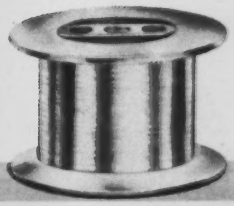
for warehouse delivery of Allegheny Stainless, call RYERSON

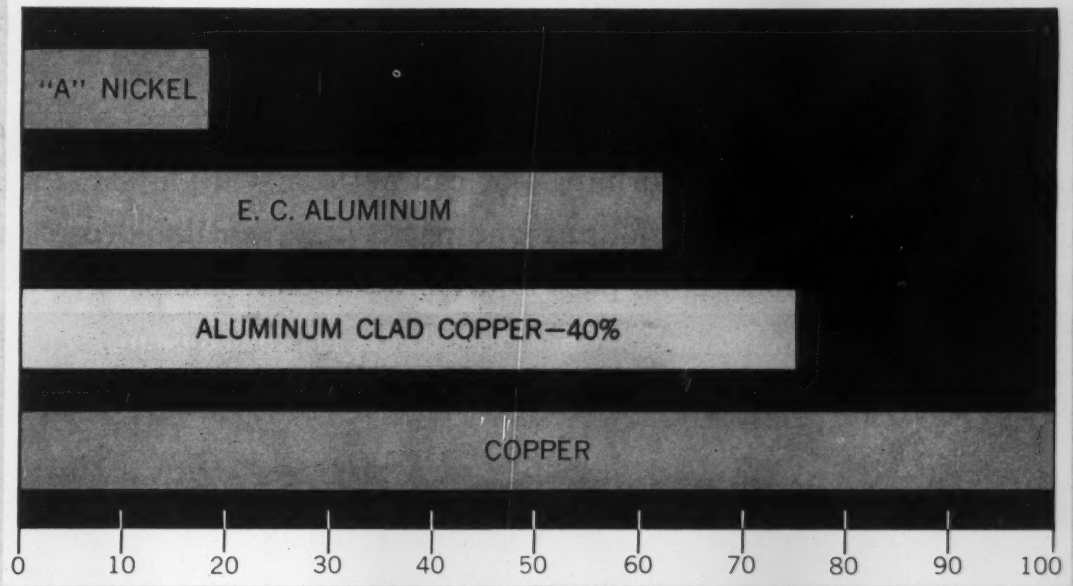
Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

For more information, turn to Reader Service card, circle No. 423

New Wire-from Sylvania





Aluminum Clad Copper-40%

Combines the surface, temperature and weight advantages of aluminum with the superior conductivity of pure copper

A new high-conductivity, aluminum clad copper wire designed for the production of high-temperature magnet wire and for high-temperature applications in aircraft, missiles and high-speed industrial equipment has been developed by Sylvania. It can withstand operating temperatures up to 700°F.

The new wire has a conductivity at room temperature approximately 75% of pure copper and considerably higher than pure aluminum. The aluminum cladding measures approximately 40% of the cross-sectional area of the wire.

In addition to its surface, temperature and conductivity advantages, the new aluminum clad copper wire is ready for anodizing to provide a self-insulating surface. Space, weight and cost savings should be of interest to all producers and users of magnet wire.

For further information on new aluminum clad copper, contact your Sylvania Parts Division representative or write to:

SYLVANIA ELECTRIC PRODUCTS INC.
Parts Division, Warren, Pa.

SYLVANIA

PARTS DIVISION

Custom Molded Plastics
Custom Metal Stampings
Custom Welded Parts
Custom Assemblies
Alloy, Clad, Plated Wire
Plated Metal Strip
Electronic Components
Fluorescent Components

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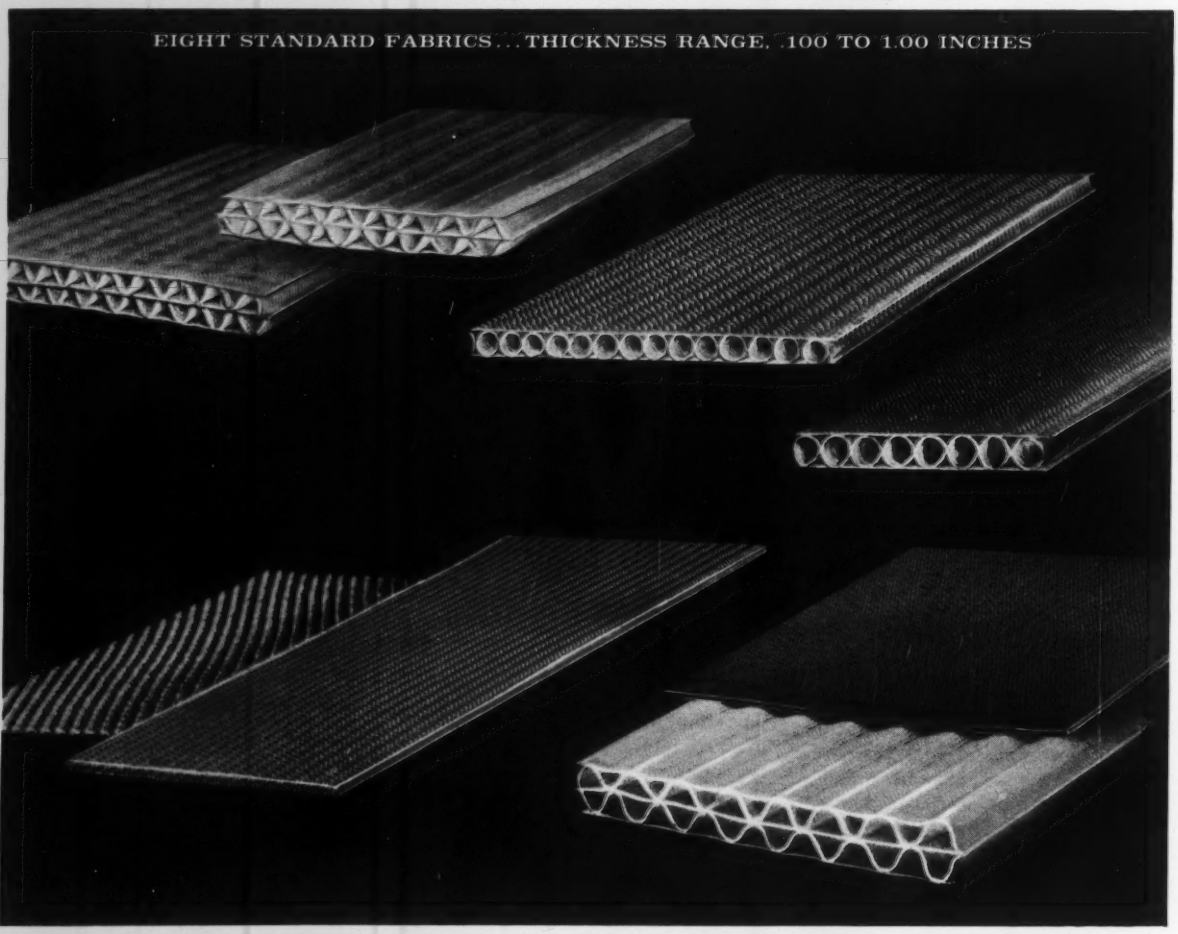

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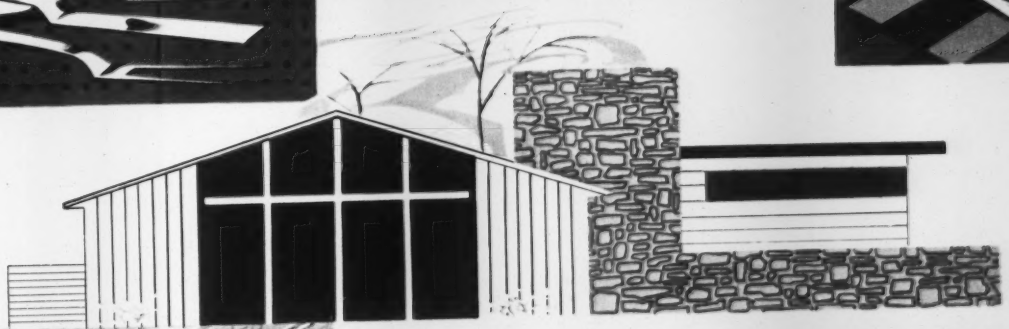

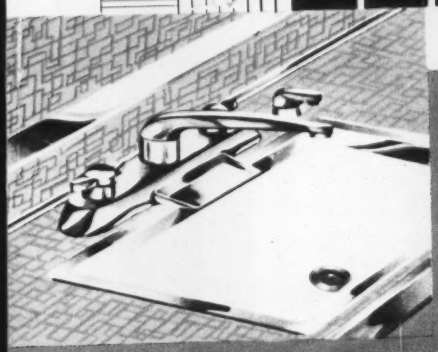

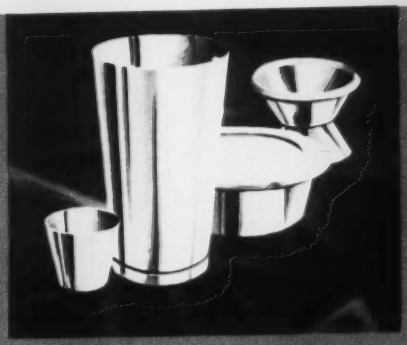

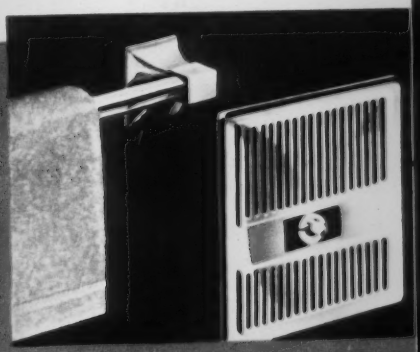

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Suppliers' New Bulletins

Cemented Carbide Parts. Allegheny Ludlum Steel Corp., Carmet Div., 32 pp, illus., No. C-16. Dimensional data, design information, prices and uses of cemented carbide parts. 1

Aluminum Forgings. Aluminum Co. of America, 36 pp, illus. Properties and uses of aluminum forging alloys. Shows company's forging facilities. 2

Stainless Steels. Armco Steel Corp., 6 pp, illus. Information on new grades of stainless steel and new facilities for producing stainless steel shapes. Information also on surface finishes for stainless steel. 3

Seamless Steel Tubing. Babcock & Wilcox Co., Tubular Products Div., 2 pp, No. TDC-115D. Chart listing permissible variations in diameters and wall thicknesses of round, seamless carbon and alloy steel mechanical tubing. 4

Metal Stampings. Bettcher Mfg. Corp., 4 pp, illus. Information on fabricating, welding, phosphating, painting and assembly of metal stampings. 5

Seamless Copper Tubing. Calumet & Hecla, Inc., Wolverine Tube Div., 16 pp, illus. Shows facilities for manufacturing seamless copper and copper alloy tubing. 6

Investment Castings. Casting Engineers, Inc., illus. Design information, properties and uses of close tolerance investment castings made by the Minicast process. 7

PVC Dispersion. Chemical Products Corp., 14 pp, illus., No. 144. Properties and uses of a specially formulated, high molecular weight, polyvinyl coating and molding material called Chem-O-Sol. 8

Reinforced Plastics Parts. Cincinnati Milling Machine Co., Cimastra Div., 12 pp, illus., No. M-2068. Information on design, quality, color and properties of reinforced plastics parts. 9

TFE Tapes. Connecticut Hard Rubber Co., 4 pp, illus. Physical and electrical properties, and uses of pressure-sensitive TFE tapes. 10

Steel Wire. Continental Steel Corp., 12 pp, illus. Information on standard and special-shaped wire, coarse round wire, and fine and specialty wire made of low and medium-low carbon steel. 11

Decorative Glass. Dearborn Glass Co., 14 pp, illus., No. 26-A-5. Uses for a line of glass products made of safety glass into which decorative inserts are laminated. 12

Solid Urethane Parts. Disogrin Industries, Inc., Marketing Services Dept., 8 pp, illus. Discusses the use of solid polyurethane rubber for wheels, seals, valve seats, belts, diaphragms and liquid oxygen containers. 13

Fir Plywood. Douglas Fir Plywood Assn. Acoustical properties, bending radii, deflection and uses of fir plywood. 14

Alloy Resistance Wires. Wilbur B. Driver Co., 4 pp, illus. Briefly discusses the use of alloy resistance wires in electronic instruments, such as digital computors. 15

Rubber, Plastics Parts. E. I. du Pont de Nemours & Co., Inc., Elastomer Chemicals Dept., 12 pp, illus., No. 85. Current issue of "Elastomers Notebook" discusses neoprene tank linings, polyurethane foam tank covers, neoprene cement and Hypalon pump linings. 16

Extruded Wire Jacketing. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., 16 pp, illus., No. WC-2. Describes extrusion techniques for applying polyethylene resins, flame-retardant plastics and nylon resins to wires and cables. 17

Rolled Steel Rings. Edgewater Steel Co., 12 pp, illus. Representative sections and dimensions of rolled steel rings. Describes process by which rings are formed from solid blocks of steel. 18

Porcelain Enameled Parts. Erie Ceramic Arts Co., 20 pp, illus. Describes porcelain enameling and discusses its use as a permanent finish for instrument dials, name plates, ashtrays, medallions and highway markers. 19

Welded Steel Tubing. Formed Steel Tube Institute, Inc. Sizes, grades and shapes of welded tubing made of carbon and stainless steels. 53

Ceramics. Centralab, Div. of Globe-Union Inc., 16 pp, illus. Mechanical, electrical and environmental characteristics of ceramics. Information on the advantages and disadvantages of various ceramic fabricating techniques. 20

Brazing Alloys. Handy & Harman, 4 pp, illus., No. 80. Information on the use of silver brazing alloys for joining cast iron to steel, stainless steel, copper, brass, cemented carbides and Monel. 21

Nickel Alloy Cast Iron. International Nickel Co., Inc., 28 pp, illus. Mechanical and physical properties, erosion and corrosion resistance, high temperature strength and uses of a nickel alloy cast iron called Ni-Resist. 22

Asbestos-TFE Gaskets. Johns-Manville, 20 pp, illus. Chemical, electrical, and mechanical properties, sizes, installation data and uses of asbestos-TFE gaskets, packings, sheets, tapes, tubes, rods and parts. 23

Aluminum, Steel Shims. Laminated Shim Co. Specifications and dimensions for laminated shims made of aluminum, as well as stainless steel, brass and mild steel. 24

Steel Bars. La Salle Steel Co., 4 pp, illus. Information on strength, machinability and tolerances of an improved high strength, free machining steel bar called Stressproof. 25

Plastics Parts. Madan Plastics Inc., 4 pp, illus. Information on injection molded, and vacuum and drape formed plastics parts. Shows company facilities. 26

Tin. Malayan Tin Bureau, 6 pp. Current issue of "Tin News" gives information on the production, consumption, uses and prices of tin. 27

Metal Powder Parts. Metal Powder Industries Federation, 8 pp, illus. Sixteen case histories on the use of metal powders in the production of cams. 53

Thermostat Metals. Metals & Controls Corp., General Plate Div., 4 pp, illus., No. TRU-8. Thermal deflections, and mechanical and restrained forces for 40 different thermostat metals. 28

Tungsten Carbide Coating. Metallizing Engineering Co., Inc., 4 pp, illus., No. 139. Wear resistance, strength and uses of a tungsten carbide hard facing powder. 29

Silicone-Base Coatings. Midland Industrial Finishes Co., 4 pp, illus. Heat, chemical and corrosion resistance, application data and uses of silicone-base coatings. 30

Molded Fiberglass. Molded Fiber Glass Companies, 32 pp, illus. Mechanical, electrical and chemical properties of molded fiberglass. Describes fabricating and finishing operations performed by the company on this material. 31

Extruded Plastics Sheets. Midwest Plastic Products Co., illus. Information on extruded plastics sheet materials made of cellulose acetate, polystyrene and polyethylene. 32

Low Static Polystyrene. Monsanto Chemical Co., Plastics Div., 8 pp, illus. Electrical, mechanical and thermal properties, and molding instructions for two "low static" polystyrene formulations. 33

Carbon-Graphite. Ohio Carbon Co., 8 pp, illus. Heat resistance, design information, mechanical properties and uses of carbon-graphite. 34

Wrought Copper. Western Brass Sales, Metals Div. of Olin Mathieson Chemical Corp., 14 pp, illus. Corrosion resistance, composition, available forms and physical properties of wrought copper and copper-base alloys. 35

Vinyl-Metal Laminate. O'Sullivan Rubber Corp., Metal Laminate Div., 6 pp, illus. Physical and chemical properties, uses, heat resistance and fabrication of a vinyl plastics sheeting that can be adhesive-bonded to steel, aluminum or magnesium. 36

Strippable Vinyl Coatings. Pennsalt Chemicals Corp., Metal Processing Dept., 4 pp, illus. Discusses the use of strippable vinyl coatings for protecting metal, wood and plastics parts during chemical treatments, and forming, stamping and blanking operations. 37

Silica Foam Insulation. Pittsburgh Corning Corp., 4 pp, illus., No. FS-1. Physical properties, uses, installation data, heat resistance, and shapes and sizes of a silica foam insulation. 38

Ferromagnetic Materials. Polymer Corp. of Penna., 4 pp, illus. Physical and electrical properties, uses and heat resistance of ferromagnetic materials. 39

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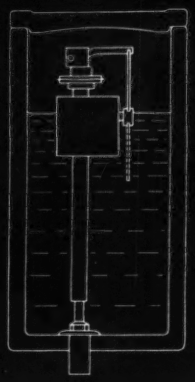

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TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, Izod (1/8" x 1/2" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (1/8" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
Dept. 102-C 744 Broad Street, Newark 2, N. J.

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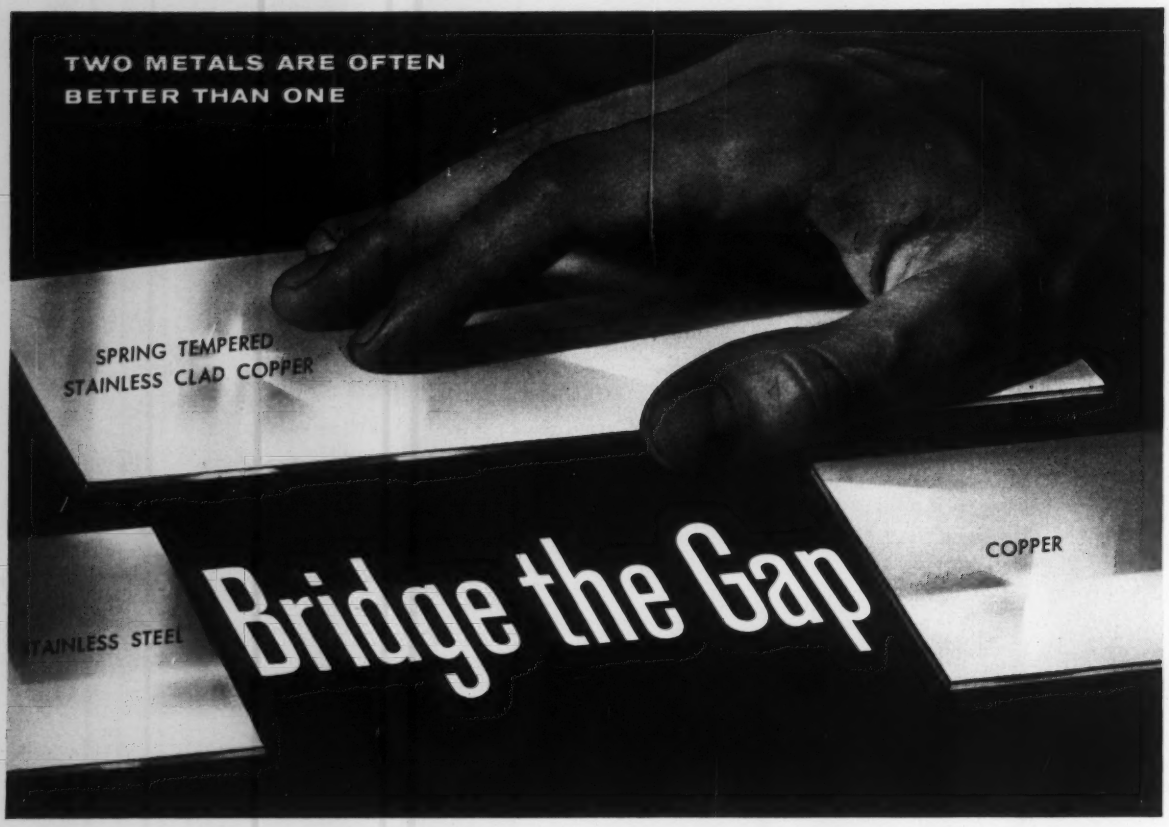

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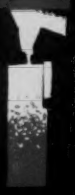

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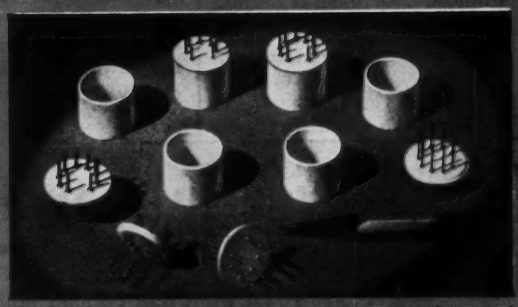

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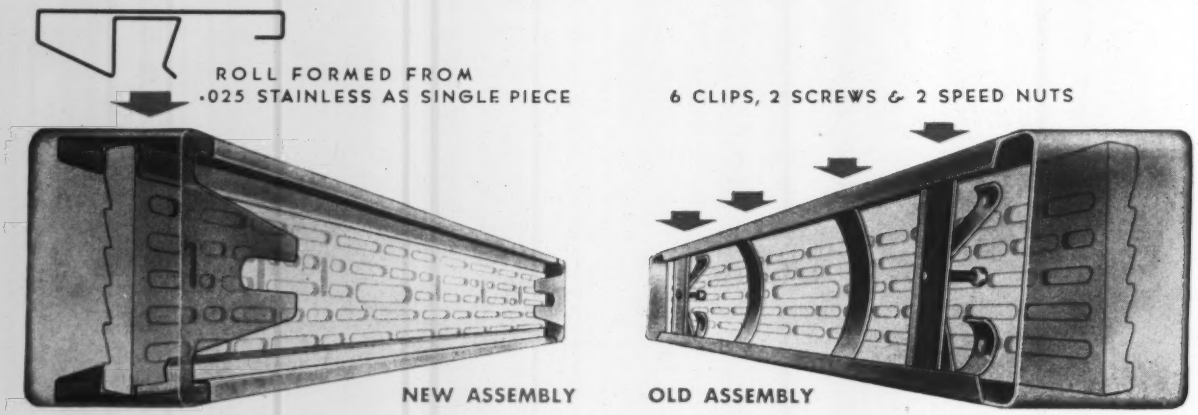
how one Roll Formed shape *eliminated six clips* and simplified an assembly



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An expensive stamping and six clips went into this assembly. The stamping had a bad finish and cracked. Now it's Roll Formed from stainless. The finish is bright, shining and can't stain in use. Cracks are eliminated.

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With the stamping the customer inserted a plastic strip and then welded the clips to retain the strip. Screws were positioned manually. Stampings were not uniform. Plastic breakage was high. The new Roll Formed section eliminates the welding operation, guarantees close tolerances, eliminates plastic breakage and cuts assembly time. Screws are not needed.

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Rejects were high. Components were hard to get and stampings came from separate suppliers. Deliveries were off-schedule. Now—Roll Formed sections come from one source and are delivered weekly to an open order. Stainless sections are interwoven with paper to protect finishes. Rejects have been eliminated.

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Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered free of burrs to match your production schedule.

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COORS HIGH STRENGTH ALUMINA CERAMICS

Mechanical Properties

PROPERTY	UNITS	COORS DENSE HIGH STRENGTH ALUMINA CERAMICS			
		AD-85 (85% Al_2O_3 Porcelain Type AD-85)	AP-995 (99.5% Al_2O_3 Special Type AP-995)	AD-94 (94% Al_2O_3 Porcelain Type AD-94)	AD-998 (99.8% Al_2O_3)
Tensile Strength At 70° F	PSI	18,600	25,600	24,600	28,000
1000° F	PSI	8,000	18,000	13,000	22,000
Compressive Strength	PSI	Over 140,000	Over 300,000	Over 300,000	Over 300,000
Flexural Strength	PSI	45,000	45,000	45,000	50,000
Modulus of Elasticity	PSI	31.9×10^6	48.2×10^6	43×10^6	52×10^6
Specific Gravity		3.46	3.61	3.72	3.90
Porosity		Zero	Zero	Zero	Zero
Hardness	Rockwell 45N	73	78	78	82
Working Temp. (max.)	°C (°F)	1400 (2550)	1700 (3100)	1700 (3100)	1723 (3140)
Specific Heat	.370 per lb.	0.18	0.189	0.19	0.2
Thermal Coefficient of Expansion					

To some engineers the mention of "ceramics" brings to mind a weak, fragile type of material good only for flowerpots or cups and saucers. That is understandable because most of us have had reason to be cautious in the handling of porcelain and china dishes.

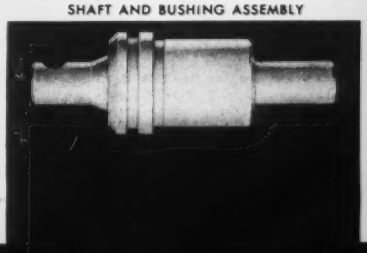
The word "ceramics" bears the same relation to the Ceramics Industry that the word "iron" bears to the Iron and Steel Industry. For thousands of years the Ceramics Industry made little progress while the Iron and Steel Industry was moving forward—developing from ordinary "pig iron" a whole family of alloy steels which bear little resemblance to pig iron.

In recent years, however, the Ceramics Industry, under the impetus of an insistent and increasing demand for materials which will withstand severe corrosion, erosion and temperatures beyond the range of metals, has made giant strides in developing techniques and new materials suitable for Space Age uses.

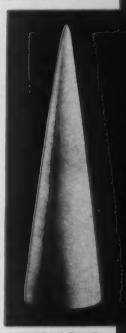
COORS PORCELAIN COMPANY has been the leader in perfecting new manufacturing techniques and new ceramic materials for the Space Age.

The famous Isostatic Process for forming homogeneous, "stress free" products was perfected by Coors for use in the production of mechanical and electrical parts for industrial equipment. This made possible the development of Coors High Strength Ceramics and their use for applications where, formerly, only metals could be used.

BENDIX AVIATION CORPORATION
SHAFT AND BUSHING ASSEMBLY



In addition to the Isostatic Process, Coors employs all other recognized methods for the production of ceramic parts and, therefore, is in a position to select the production technique best suited for a specific job.



NOSE CONE

Coors production facilities are capable of turning out products ranging all the way from a crude ball mill lining brick to high precision gauge blocks.

An indication of the type of high precision work that can be done by Coors is the shaft and bushing assembly made for Bendix Aviation Corporation and illustrated here. On this assembly, dimensional tolerances are held as close as $\pm 0.000015''$.

Applications for COORS SPACE AGE CERAMICS are found in all major industries where ordinary materials do not stand up.

Parts made of these ceramics are found in a wide range of equipment—from atomic submarines to missiles. Some of the applications include pump plungers for pumps used in the oil, chemical and other industries; cylinder liners for pumps; orifices and nozzles for many types of equipment subject to abrasion; oil well tubing protection sleeves; wire guides; rollers; cups for gas-arc welding equipment; valve parts; mechanical shaft seal parts; wear plates; welding locators; extrusion dies, etc.

PUMP PLUNGER

MECHANICAL SEAL RING

Coors offers a complete engineering service to assist you in utilizing these high strength ceramics to the best advantage. For complete specifications, write for Bulletin 858.

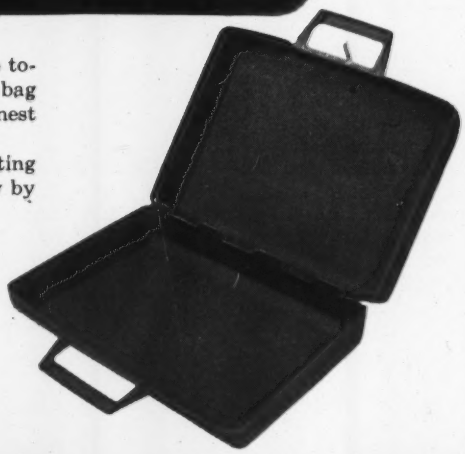
Coors
PORCELAIN COMPANY
600 Ninth St., Golden, Colorado

Pan Am's new Passenger Travel Bag made of.....

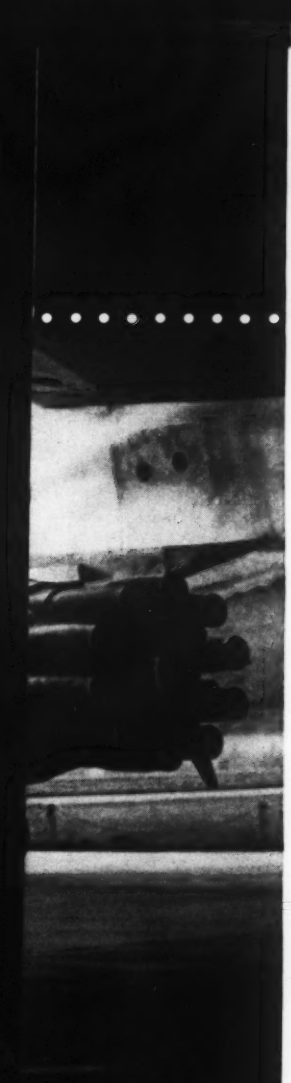
Formed from two identical injection molded shells which snap together through an integral hinge, the new Pan Am travel bag represents the latest word in luggage design! The two shells nest together for storage and shipping.

Handles, hinge, joint laps and color are all integral, eliminating costly secondary operations. Mold cost was of course kept low by the double use of one cavity to make a complete case.

The use of MARLEX guaranteed light weight, good rigidity and an attractive surface . . . sufficient toughness and flexibility for hinge detail . . . good molding characteristics and low material cost.



Designed by Edward Larrabee Barnes Associates, New York, N. Y.
Development and engineering coordinated by Plastic Engineering Sales Company, New York, N. Y.
Mold construction by Standard Tool Co., Leominster, Mass.
Manufactured by Penn Plastics Corp., Glenside, Pa.



...MARLEX*

...designed with integral handles and hinges!

The latest idea in high-speed travel is jet aircraft . . . and the latest idea in overseas passenger flight bags is this brand new design in MARLEX rigid polyethylene.

Unlike the current sewn fabrics and vinyl bags, the MARLEX flight bag is strong and rigid—styled to look like an expensive luggage item—but priced to compete with bags formerly used.

Combining light weight with unusual strength, toughness and durability, MARLEX offers manufacturers the ultimate in plastic quality at a price that opens up new design horizons. Items that never could have been made before because of the expense of raw materials or fabricating methods are now being mass-produced from MARLEX.

No other type of material can serve so well and so economically in so many different applications.

How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

Charles Forberg and Donald Davidson of Edward Larrabee Barnes Associates, New York, were the designers of this attractive and functional travel bag. In addition to modernizing their travel bag, Edward L. Barnes Associates redesigned all of Pan Am's plane interiors and advertising materials, as well as their overall corporate image.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

MARLEX
Phillips 66
A PHILLIPS 66 PLASTIC

PLASTICS SALES OFFICES

NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN	EXPORT
322 Waterman Avenue	80 Broadway, Suite 4300	318 Water Street	111 S. York Street	317 N. Lake Ave.	6010 Sherry Lane	80 Broadway, Suite 4300
East Providence 14, R.I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena, Calif.	Dallas, Texas	New York 5, N.Y.
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	RYan 1-6997	EMerson 8-1358	Digby 4-3480

For more information, turn to Reader Service card, circle No. 483

Another Tinnerman Original...

Cost-cutting Tubular **SPEED CLIP®** takes positive "bite" to hold assemblies tight!

In seconds, you can front-mount trim, name plates, grilles, knobs, insulation, with Tubular SPEED CLIPS. And at interesting savings in assembly time and costs!

Snap these quality spring-steel fasteners into holes in metal, plastic or wood. Then press the mounting studs, nails or rivets into the clips to complete the attachments... anywhere along your assembly line.

As the SPEED CLIP is inserted, spring fingers compress, then expand behind the panel to lock tight. The rolled-in end permits easy entrance, but bites hard into the stud to prevent back-off or vibration-loosening.

Tubular SPEED CLIPS are available for a full range of stud sizes and panel thicknesses. Permanent lock or removable types.

Check your Sweet's Product Design File (Section 8/Ti) for data on Tubular SPEED CLIPS and other SPEED NUT brand fasteners. Then call your Tinnerman representative for samples and additional information. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

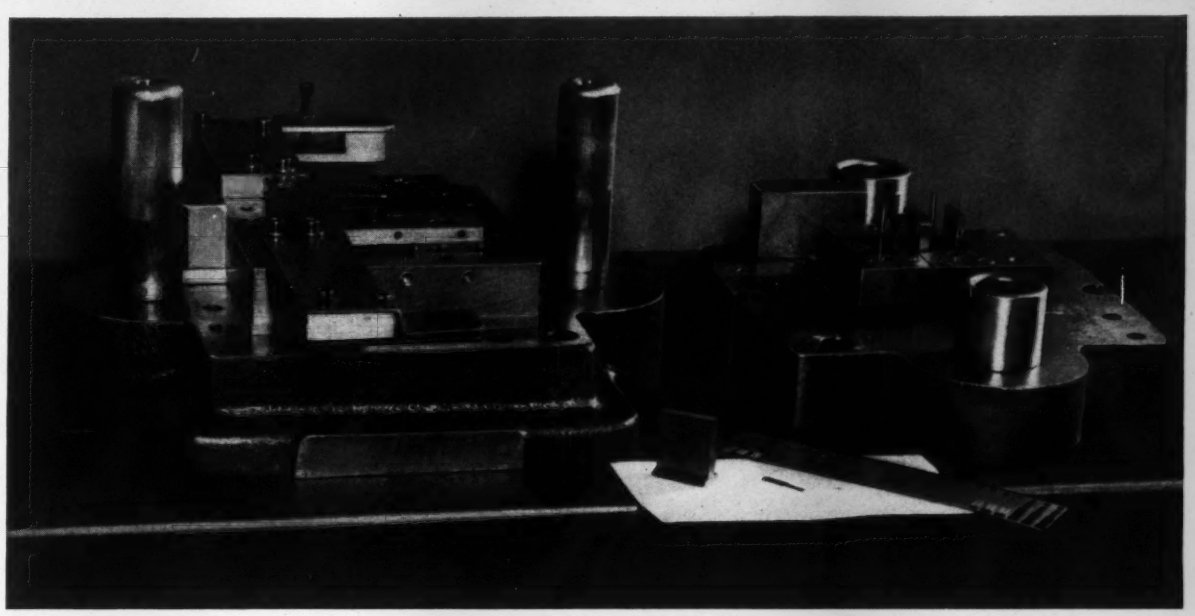
FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Bundy GmbH, Heidelberg.

For more information, turn to Reader Service card, circle No. 470

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.



Blanking Die Output Doubles When Bearcat Takes Over

At the Remington Rand Division of Sperry Rand Corp. they were getting up to 50,000 pieces from a set of dies that blanks and forms grooved pins from .025-in. steel strip. Our local tool steel distributor, Leed Steel Co., suggested a change to our Bearcat tool steel. Result? The output increased to about 100,000 before the die needed reworking.

Bearcat has exceptional resistance to wear and shock. Because of its air-hardening characteristic, Bearcat minimizes quenching hazards and distortion in heat-treatment.

WIDE RANGE OF APPLICATIONS

In addition to blanking and forming jobs, Bearcat can be used economically in such varied applications as shear blades, punches, rivet sets, hot headers, die-casting die inserts, and master hobs. In fact, wherever the job calls for a grade having unusual toughness, Bearcat is the answer.

Your Bethlehem tool steel distributor carries Bearcat in stock in a wide size range. He's ready to serve you at a moment's notice. Give him a call today.

←Memo to Die-Casters:

USE CROMO-HIGH V (H-13)

You can't go wrong when you choose Bethlehem Cromo-High V (AISI-SAE H-13) for die-casting. This 5 pct chromemoly grade, with 1 pct vanadium, has good resistance to wash and erosion, plus plenty of toughness. It's uniformly annealed, for easy machinability. It also has good center density and grain refinement, and is free from porosity.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

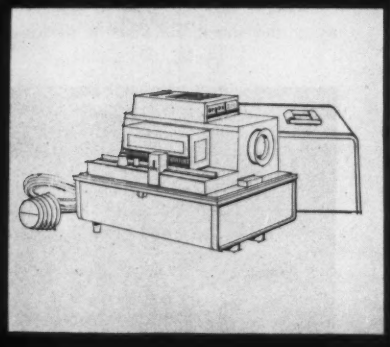
Periodic Regrinding Improves Tool Life

The service life of many types of tools can be improved if the tools are periodically reground at intervals before they have deteriorated to a degree which impairs their function.

This practice is particularly useful when applied to tools which repeatedly fail in service by fatigue, chipping, spalling, or cracking through heat checks. The objective of preventative grinding is the removal of service-damaged metal before the damage progresses to a depth which would not be removed in normal redressing operations. It is an application of the old proverb, "A stitch in time saves nine," and is just as appropriate when applied to tools as to a small rip in a piece of wearing apparel.

The point at which regrinding should be done during the service of a given tool must be developed by experimental work. It is most practical if it can be made to coincide with a normal shutdown of an operation for other reasons.

Shaping the



Design by Harley Earl Associates
Arvinyl and fabrication by Arvin Industries, Inc.

new world of product design

ARVINYL

This new metal laminate gives you endless opportunities for improved product life and looks. Arvin's fabricating skill and experience provide superior quality and cost saving in start-to-finish production.

Combining the durability of metal, the personality of fabric and cleanability of plastic—plus extreme resistance to abrasion, temperature and corrosion—Arvinyl offers a vast range of application to new-product design and existing-product improvement, with enormous advantages of styling, colors, texture.

Arvin "one-stop" fabrication facilities

To the inherent advantages of Arvinyl, Arvin adds a complete fabrication service unique in scope and thoroughness. For working with designers, Arvin has a prototype department and a plastic tool and die shop for building mockups. Through continuous research and experiment, Arvin has perfected techniques for deep-drawing Arvinyl into almost any form—with vinyl laminated to steel, aluminized steel, steel electrolytically coated with zinc, galvanized steel, aluminum or magnesium.

Cost savings

Arvinyl can save you money in consistent "finish-perfect" fabrication, simple tooling and virtually no trim scrap. Arvin's "one-stop" facilities save you materials-handling and other direct and indirect labor costs.

Exclusive Aluma-Lok* method

Aluma-Lok*, developed by Arvin, is a procedure for applying aluminum channels to Arvinyl sheets in the flat *before* forming—as in the Argus case described below. In addition, Arvin has methods for laminating both sides of metal, and for magnetic-force spot welding Arvinyl to light or heavier gauges of steel—without burning or marring the vinyl surface.

Let us consult with you—no obligation

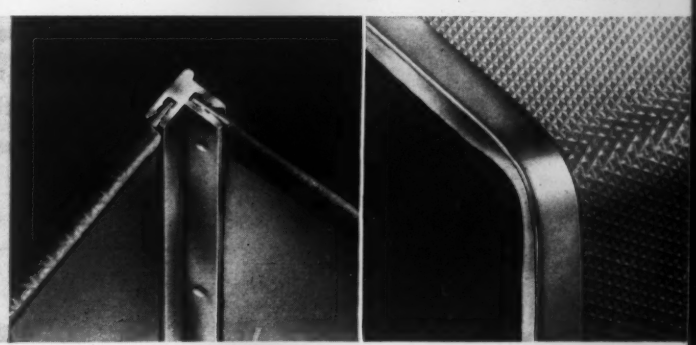
Besides the Argus projector case, Arvin has fabricated Arvinyl into a wide variety of products, including television and phonograph cabinets, portable radio cases, automobile console and seat panels—and Arvinyl has been supplied in sheets for many other products. It is a particularly useful material in the field of office equipment, for enclosures for typewriters, tape recorders, calculators, dictating machines, etc. Designers are invited to let their imaginations run and to bring to our consulting staff any projects which contemplate new design. No obligation. Write for descriptive brochure, Dept. AM39.

Arvinyl Division, Arvin Industries, Inc., Columbus, Indiana

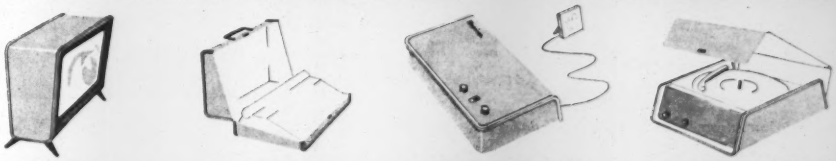
**Patent applied for*

NEW ARGUS PROJECTOR CASE

Two-channel aluminum frames, extruded by Arvin, are applied in the flat to two edges of the wrap-around section, which is then formed by Arvin's Aluma-Lok* technique. End pieces are slipped into channels and mechanically locked into place. Interior is painted, latches and plastic handle (also made by Arvin) are applied and the case is complete. Tooling is simple and there is virtually no trim scrap. Result: A better-looking, better selling case, with greatly improved resistance to damage—and produced at lower cost than the previous pyroxylin-covered wood case.



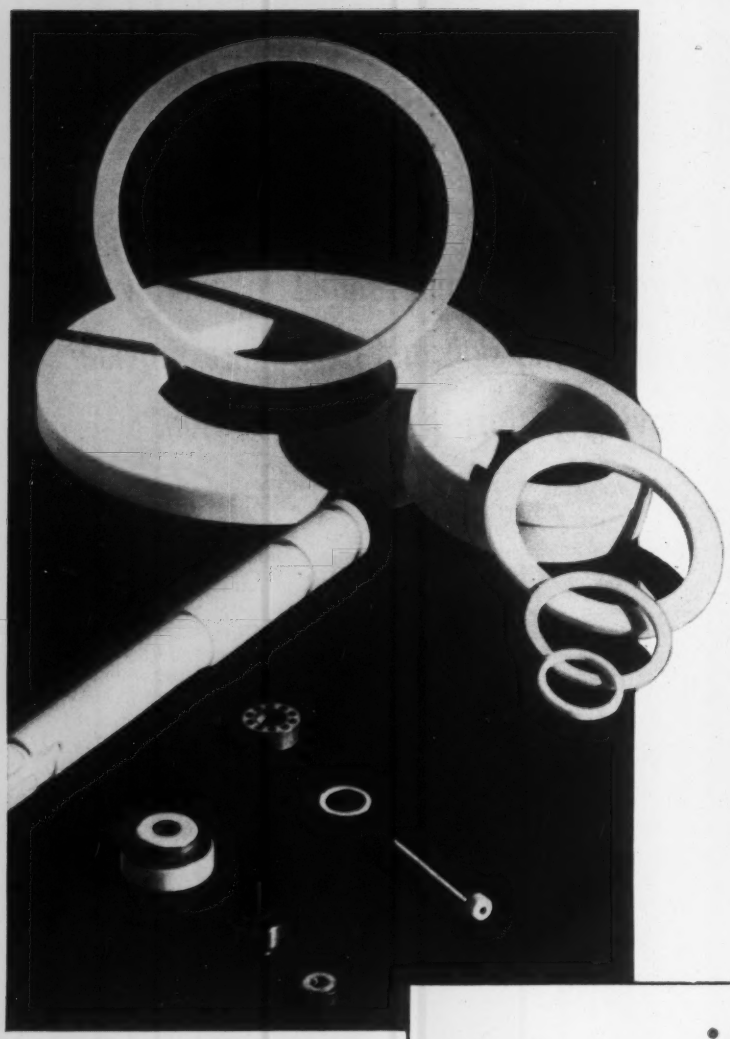
Aluma-Lok is ideally suited to almost any type of cabinet or enclosure for products such as:*



TELEVISION TYPEWRITERS DICTATING MACHINES RECORD PLAYERS

For more information, turn to Reader Service Card, circle No. 390

Maybe that *special material* you need is...



ALITE

Throughout industry, design engineers are discovering the remarkable qualities of Alite — and are using Alite's unusual combination of desirable properties to improve existing products or create new ones.

The Alites are a series of high-alumina ceramics especially developed by U. S. Stoneware to meet the demands of higher thermal shock resistance, greater mechanical strength, and better electrical properties, to name just a few. Alite is vacuum-tight, can be metalized and fabricated into hermetic ceramic-to-metal assemblies for rugged service in a host of critical applications, both electrical and mechanical.

If you have a materials problem in the mechanical, electronic or nucleonic fields, designing for Alite could well be the answer. We invite inquiry on your specific applications.

Have you been looking for a material with properties such as these?

- **Superior mechanical strength**
- **Extreme hardness**
- **Exceptional abrasion resistance**
- **High temperature stability**
- **Excellent dielectric characteristics**
- **High corrosion resistance**
- **Resistant to nuclear radiation**
- **Workable to precision tolerances**

Write for this FREE idea starter

Bulletin A-7R gives advantages and possibilities of Alite, plus complete comparative data.

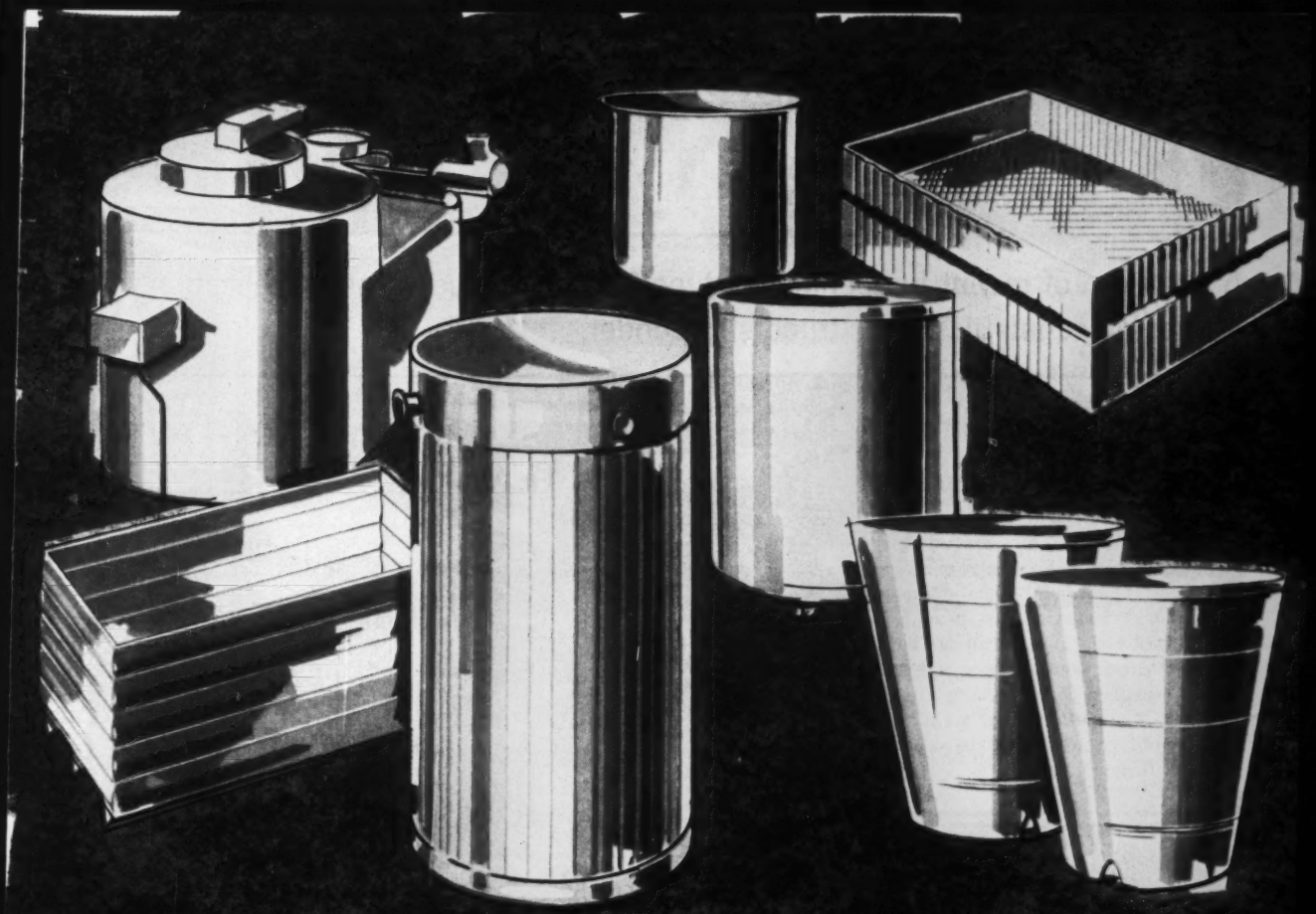
ALITE DIVISION
Orrville, Ohio

U. S. STONEWARE

1-F

For more information, turn to Reader Service card, circle No. 415

For more information, circle No. 416 ➤



*For Heat Treating Equipment**

Nothing Beats **Ingersoll** Heat Resisting Stainless

What do *you* make that might be made *better* with Ingersoll heat resisting stainless steel? *Electric furnace liners? *Annealing baskets and trays? *Retorts? *Furnace boxes and carburizing boxes? *Other heat treating equipment?

If it calls for heat resisting stainless steel, call on Ingersoll for your needs. Ingersoll heat resisting stainless is scientifically formulated to provide maximum strength and durability under high operating temperatures. And it has exceptional forming characteristics for easy fabrication into the shapes you require.

What's more, when you specify Ingersoll heat resisting stainless steel you get *customized* service. Production schedules set up to meet *your* requirements. Sheet and plate to your exact analysis, size and gauge specifications. Quality control that assures uniform high quality. On-time, as-promised deliveries to meet your own production needs.

If you use heat resisting stainless, nothing beats Ingersoll . . . or Ingersoll service. Try us, and see.

INGERSOLL STEEL B-W BORG-WARNER

Ingersoll STEEL DIVISION

Borg-Warner Corporation

NEW CASTLE, INDIANA

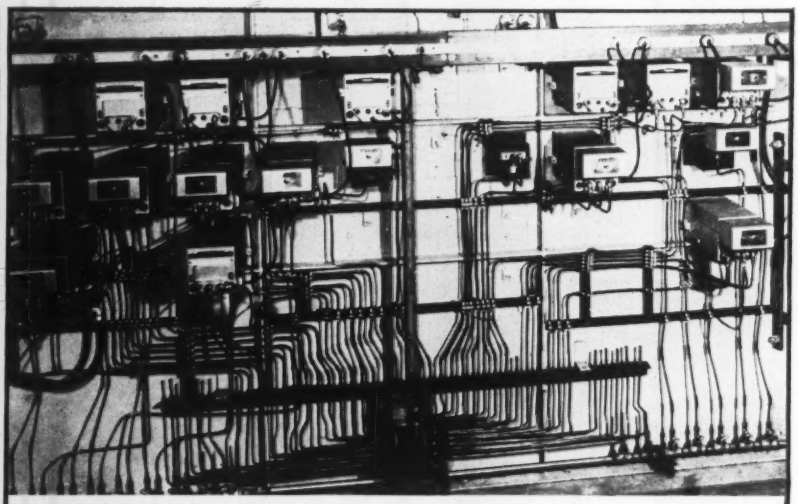
1884 75 YEARS 1959

Plaskon Nylon News

A round-up of recent happenings in type-6 nylon, including new applications... and some economics for extruders to ponder.

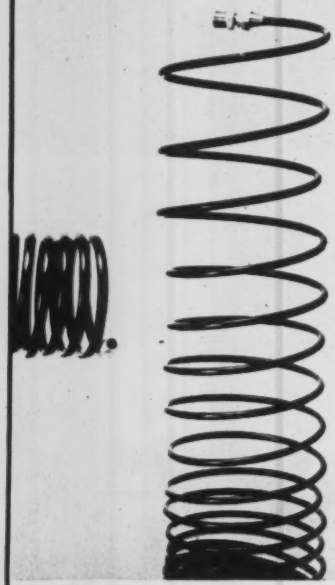
ECONOMY IN EXTRUSIONS

The question, "Is the scrap reusable?" can make or break the profit picture of any extruding operation. PLASKON Nylon Extrusion Compound 8205 maintains high-melt viscosity through successive regrinds. Scrap can be re-extruded several times without loss of basic properties. This scrap re-use often gives a sharp competitive advantage to users of PLASKON 8205.



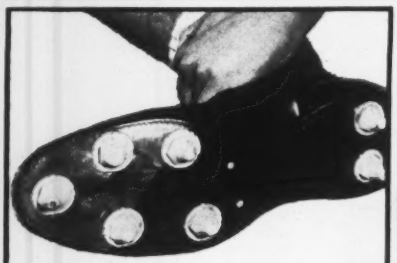
INSTRUMENTATION

Color-coded nylon tubing replaces copper in control panel at Allied Chemical's phthalonitrile plant, Edgewater, N. J. Nylon's advantages: 50% less in cost, greater corrosion resistance, easily color-coded.



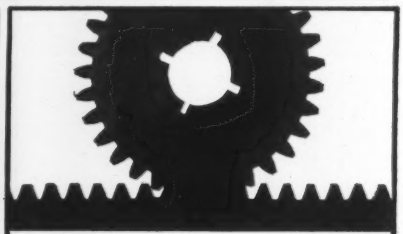
TOUGH AIR HOSE

For use with pneumatic tools, this lightweight "Nycoil" hose is extruded from PLASKON Nylon. It's tough, heat-resistant, unaffected by hydrocarbons . . . has permanent recoil action.



FOOTBALL CLEATS

Molded of PLASKON Nylon, these cleats outwear other types by a factor of 5 to 10. Their safety and durability suggest other possible applications in sports equipment.



GEAR AND RACK

Type-6 nylon has higher impact resistance than other nylons. This advantage goes to work in a gear and rack molded of PLASKON Nylon and used in Scott Company lawnmowers. The parts are more durable than the metal ones they replace.

For further information, or technical assistance, write to our Nylon Product Development Department.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

For more information, turn to Reader Service card, circle No. 510

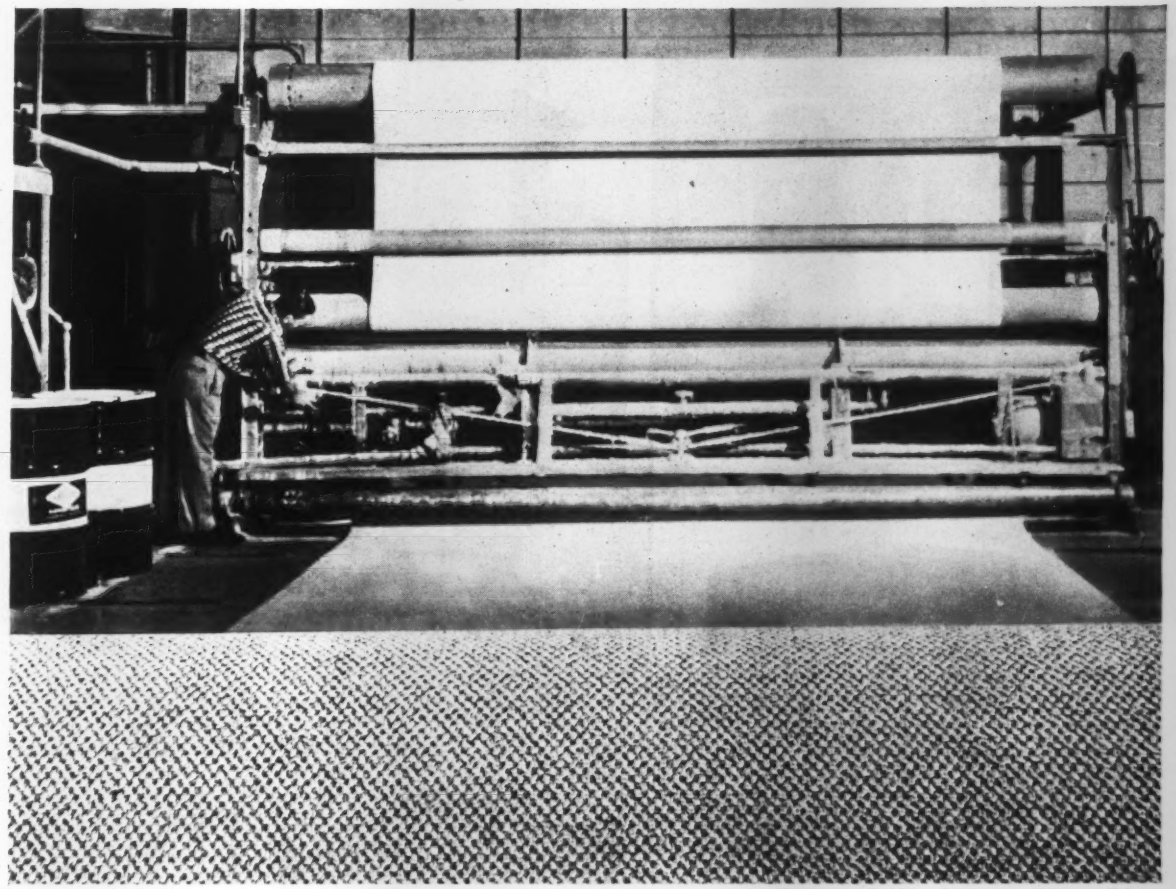


Photo courtesy Hightstown Rug Company, Hightstown, N. J.

Best way to back up a bright idea

Look closely and you will see that this is a *knitted* carpet—made by looping rather than weaving. Yet this carpet has the general appearance, good "hand" and wearing qualities of considerably more expensive woven carpeting – all of which adds up to a pretty bright idea.

How is this possible? It's due—in large part—to the backing, for the looser construction of knitted carpets demands a backing material of superior tuft-lock and fiber-binding characteristics. And these are the major reasons why one of the country's leading carpetmakers chose a combination of CHEMIGUM LATEX and PLIOVIC LATEX to back up its bright, new knitted line.

Other benefits of the backing include dimensional stability, excellent body, good color stability and nonskid properties. Moreover, it's easy to compound and apply, processes well and is permanent—thanks primarily to the CHEMIGUM LATEX.

Need a better backing for *your* bright ideas? CHEMIGUM LATEX may well be the answer. For full details – plus latest *Tech Book Bulletins* – write Goodyear, Chemical Division, Dept. C9437, Akron 16, Ohio.

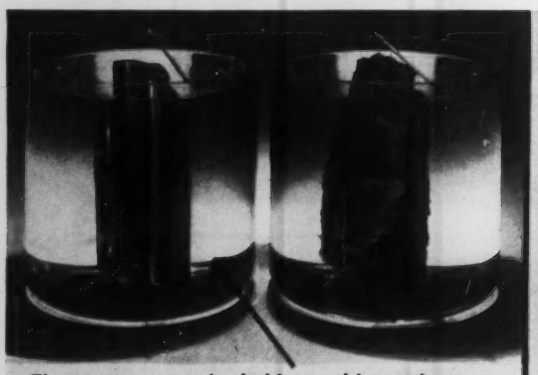
GOODYEAR

CHEMICAL DIVISION

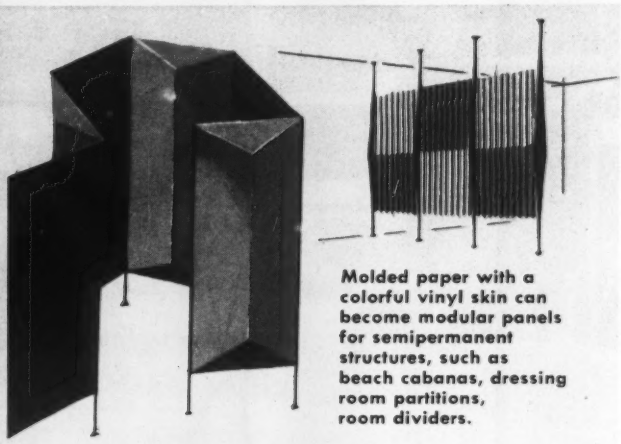
Chemigum, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

For more information, turn to Reader Service card, circle No. 428

A NEW WAY TO UPGRADE YOUR PRODUCTS: VINYL COATINGS



The transparent vinyl skin on this section of a pulp-molded shipping tray makes it impervious to water.



Molded paper with a colorful vinyl skin can become modular panels for semipermanent structures, such as beach cabanas, dressing room partitions, room dividers.

Vinyl-coated pulp-molded covers can make shipping containers that permit flat car shipping, and outside storage.

Weatherproof covered pallets of paper pulp can withstand weather—could multiply warehouse space.

Colorful, leather-y coatings for molded paper

Vinyl coatings can help you develop new products made of molded paper with its attendant advantages of low-cost tooling. You can turn molded paper pulp into an altogether new material with a single spray or dip coating.

The vinyl dispersion transforms molded paper pulp into a smooth, brightly colored weatherproof, waterproof material. A "skin" up to 60 mils thick can be put over a molded paper product and heat-cured quickly into a permanent, abrasion resistant, leathery-tough film.

You can make the coating soft and rubbery or as hard as a tire casing. The vinyl coating can be glossy, satin-y, or dull; the characteristics of the skin, like the choice of color, are determined by the formulation of the dispersion.

Write for sources of vinyl in liquid form for coating paper—or sheet metal, glass, or products of wire or expanded steel. You can open new markets with new products.

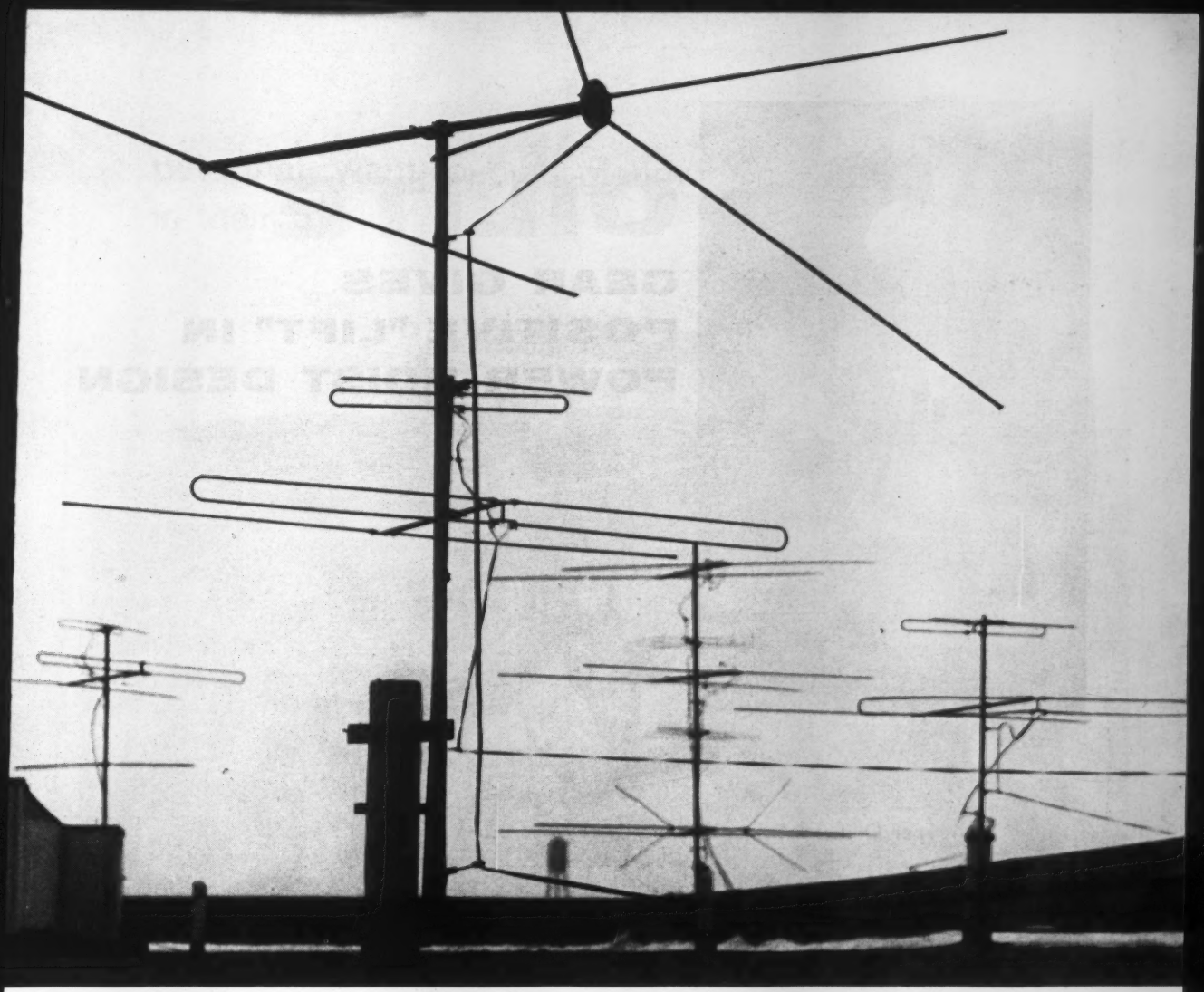
Monsanto manufactures a wide variety of plasticizers and Opalon® resins for formulators of these high-quality vinyl dispersions.

Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
*Dept. SP-6, St. Louis 24, Missouri

Monsanto®

Where Creative Chemistry Works Wonders for You

For more information, turn to Reader Service Card, circle No. 378



WHICH ONES WILL LAST (and last, and last!)?
THOSE MADE OF WEIRKOTE® ZINC-COATED STEEL!

Steel tubing that's protected against corrosion even under the most trying circumstances. Steel tubing that's easily fabricated to meet the most exacting specifications.

That's what you get in tubing made of Weirkote zinc-coated steel!

Weirkote's zinc coating—applied by the continuous process throughout, and so uniformly that every square inch is protected—is skin-tight. There's absolutely no flaking or peeling no matter how tortuous the crimping, twisting or other stresses of fabrication. In fact, Weirkote can be worked to the very limits of the steel itself.

The use of Weirkote can eliminate the need for any further coating process after fabrication. Its tight zinc coating is completely intact and remains so during fabrication and on the job. Weirkote zinc-coated steel tubing is particularly suited for jobs where weather is a factor to be taken into consideration.

Take a good long look at the possibilities and advantages of using Weirkote zinc-coated steel to meet your tubing requirements. For the complete story on Weirkote and how it can help you, write Weirton Steel Company, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

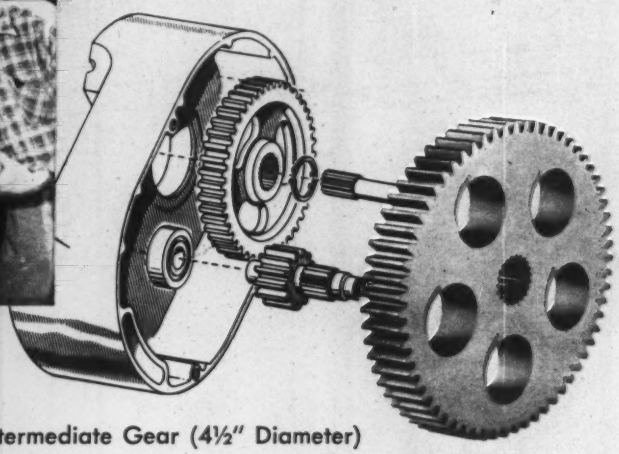
a division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service Card, circle No. 404

OILITE

GEAR GIVES POSITIVE "LIFT" IN POWER HOIST DESIGN



Super Oilite #9 Intermediate Gear (4½" Diameter)

...saves Chisholm-Moore 53¢ per unit

You can be sure this heavy-duty "Lodestar" hoist is a rugged performer capable of handling loads quickly, efficiently . . . the result of CM's 70 years experience in designing and manufacturing hoists for industry!

Only top quality parts qualify. That's why CM engineers specified "Oilite"® for the vital intermediate gear of the train. The Oilite Precision Part provided excellent mechanical properties, close tolerances and fine surface finish. Consequently, gears made of tough, wear-resistant Super Oilite #9 transmit motor power smoothly and quietly . . . have more than enough mechanical strength to assure long, trouble-free life.

Moreover, the Oilite gear is produced as a finished part requiring no machining . . . saving CM *53c on every gear used!* Chrysler-engineered Oilite Precision Parts are obtainable in many metals and alloys to give desired mechanical properties. Savings up to 55% or more are common for parts produced in volume.

Contact your local Oilite Engineer for possible savings on your parts. Look for him in the Yellow Pages under "Bearings—Oilite" or write Dept. T-3.

® Only Chrysler Makes Oilite

PM PM MEMBER

SINCE 1929

A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

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puts that "want-to-buy" gleam in their eye

UNILOY
STAINLESS STEELS

The gleam in *her* eye reflects the brilliant beauty of stainless steel trim. The gleam in *his* eye reflects the protection that only stainless steel provides. Helps keep that "showroom look" for years.

Specify Uniloy stainless steel, produced by steelmakers who have been making specialty steels since 1884. This backlog of experience explains Uniloy's gleaming finish, why it is so easy to fabricate. For prompt delivery of Uniloy stainless steel rolled to your exact specifications, write or call our nearest sales office or warehouse.

UNIVERSAL CYCLOPS
STEEL CORPORATION
BRIDGEVILLE, PA.

STAINLESS STEELS • TOOL STEELS • HIGH TEMPERATURE METALS

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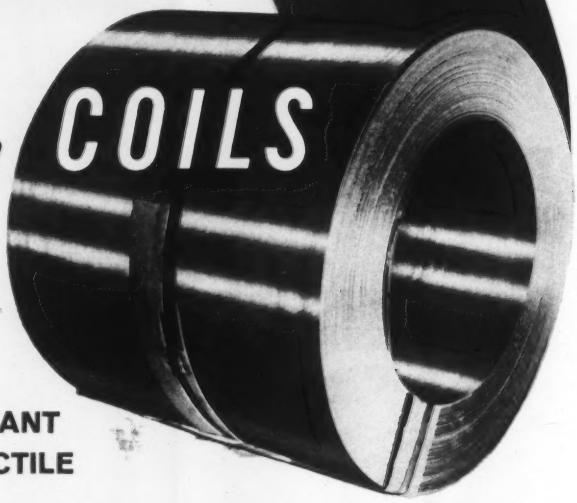
CONTINUOUS-LINE

GALVANIZING

Gives You Even More In COILS



Yes, you get the basic advantages of continuous-line galvanized sheet metal:

A CORROSION-RESISTANT ZINC COATING AS DUCTILE AS THE STEEL BASE

You can

STAMP IT SPIN IT CRIMP IT DEEP-DRAW IT LOCK-FORM IT

But you can't **FLAKE IT CHIP IT PEEL IT CRACK IT**

AND THE DIVIDEND

In Coil Form, you

- **SAVE STORAGE SPACE**
- **SLASH HANDLING COSTS**
- **REDUCE SCRAP LOSSES**
- **ELIMINATE SHEET END TRIMMING**
- **CUT ODD SHEET INVENTORIES**

Exit end of continuous galvanizing line

The St. Joseph Lead Company is in the unique position of being able to supply zinc to virtually any specification which operators of continuous galvanizing lines consider most desirable for their individual requirements.

ST. JOSEPH LEAD COMPANY

ST. JOE

250 PARK AVENUE
NEW YORK 17, N. Y.

ZN-127

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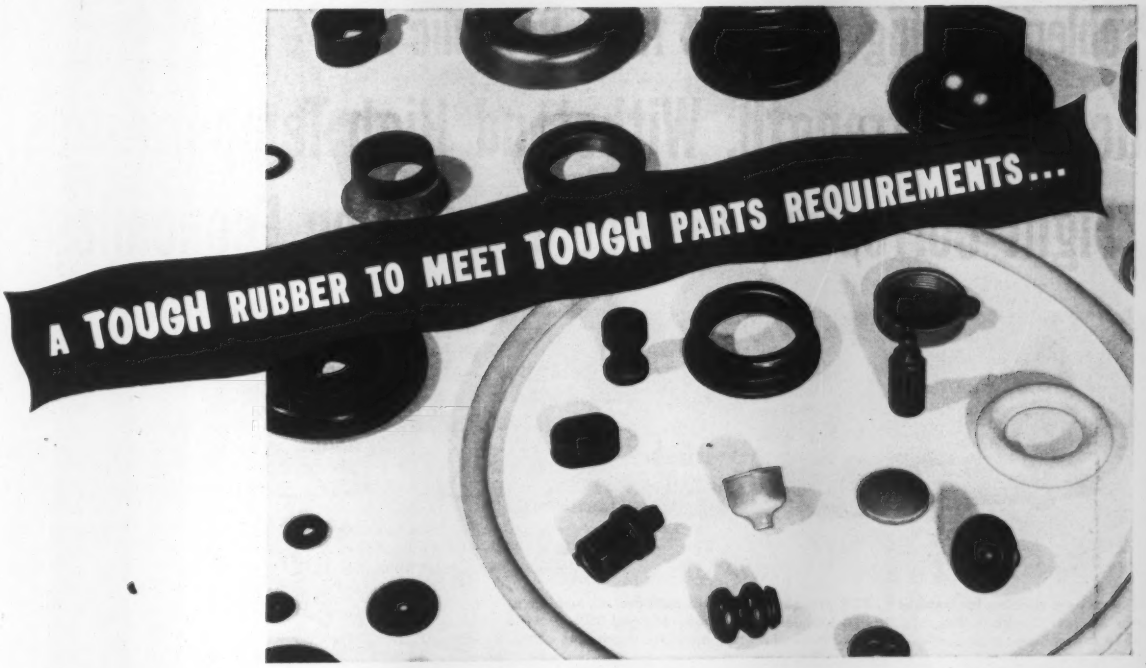

Colonial's "SILICOL"*

SILICONE RUBBER

NOW **tougher** THAN EVER . . . "SILICOL" has long been the engineers' choice for rubber parts to resist many difficult conditions of which temperature extremes, chemical attack and aging from weather and light are only typical. Because of its versatility, it is specified for all manner of applications from simple appliances to jet planes and guided missiles.

A **new** formulation of "SILICOL" now offers product designers greater versatility than ever. A few of its characteristics which can help you meet tough design requirements easier are: **TENSILE STRENGTH — 1600. ELONGATION—850%.**

The new "SILICOL" formulation is also even more important than ever to aircraft designers and manufacturers . . . In addition to the properties above, it meets AMS 3345 requirements for dry heat resistance, low temperature flexibility and oil resistance.

Whether you are designing new products, or improving existing ones, contact us for full details on "SILICOL" silicone rubber, and information on Colonial's custom rubber compounding and molding service. We can help you meet your "toughest" rubber parts requirements quickly, dependably and economically.

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COLONIAL RUBBER CO.

706 Oakwood Street — AXminster 6-9611

RAVENNA, OHIO

*Trade name of Colonial Rubber Co.

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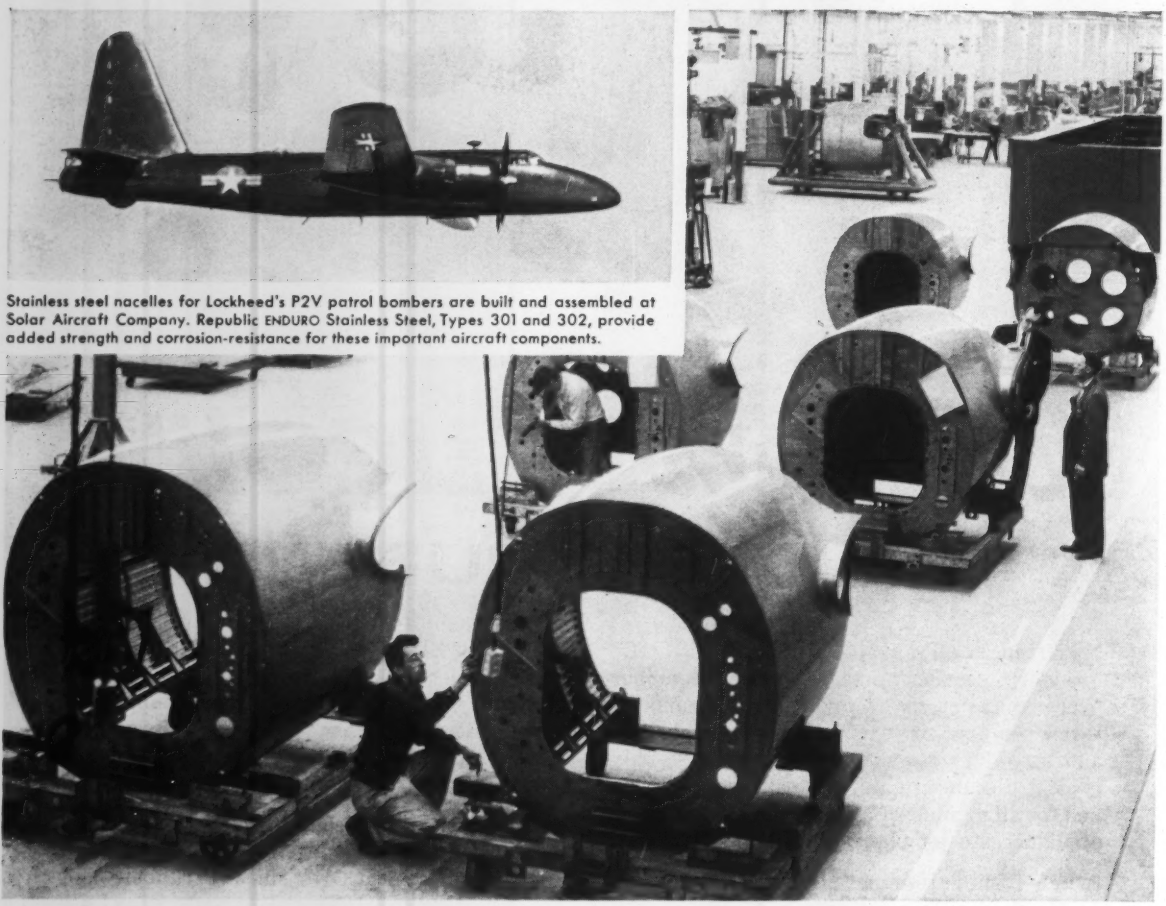
Problem-Solving Products from Republic

Increase Strength, Withstand High Temperatures, Fight Corrosion, Provide Production Economies



Stainless steel nacelles for Lockheed's P2V patrol bombers are built and assembled at Solar Aircraft Company. Republic ENDURO Stainless Steel, Types 301 and 302, provide added strength and corrosion-resistance for these important aircraft components.

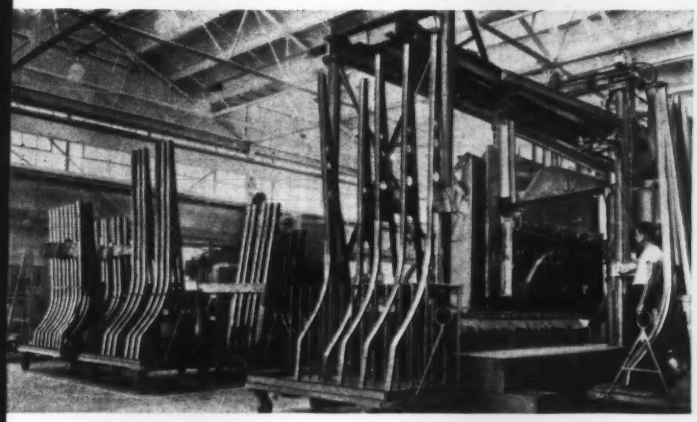
REPUBLIC ENDURO® STAINLESS STEEL HELPS SOLVE strength, heat, and corrosion problems in engine nacelles for the Navy's P2V patrol bombers.

Complete nacelles are built by Solar Aircraft Company, San Diego, California, pioneers in stainless steel airframe construction. To date, Solar has manufactured more than 1000 nacelles for Lockheed's P2V program using A.I.S.I. Types 301 and 302 Stainless Steel.

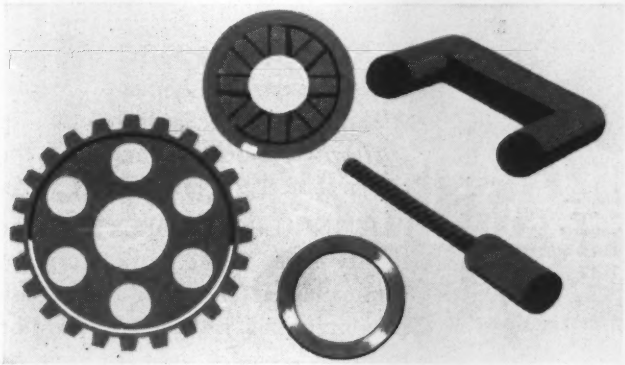
The stainless steel construction of these airframe units offers a number of advantages including greater strength, ability to withstand high temperatures, less maintenance for protection against corrosion and more economical production processes.

Republic ENDURO Stainless Steels, Types 301 and 302, provide needed strength, yet permit the use of lighter gages to save weight. They are highly resistant to atmospheric corrosion, erosion, and oxidation at high temperatures. They are readily formed into desired shapes by the usual commercial methods.

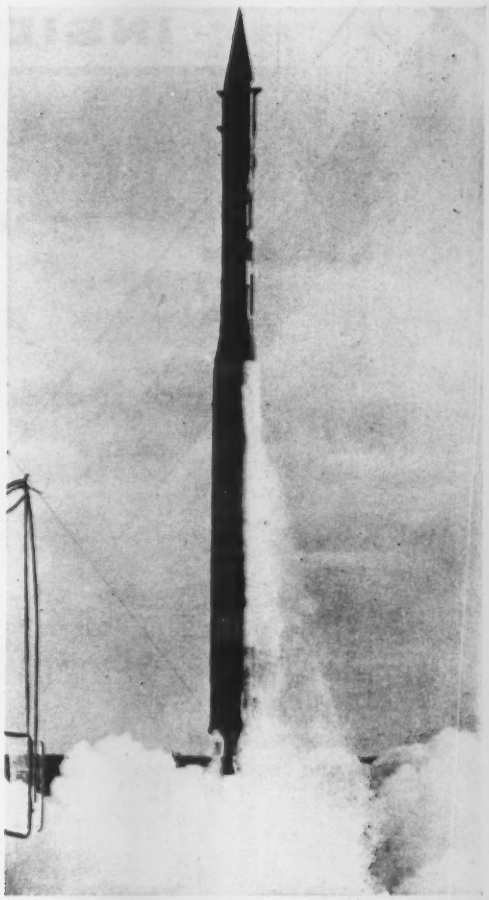
Like Solar, Republic is also a stainless steel pioneer. Republic metallurgists and engineers pioneered the development of these high strength-to-weight, heat-resistant, and corrosion-resistant metals. To help you use them to best advantage, Republic offers you the services of its famed 3-Dimension Metallurgical teams —field, mill, and laboratory metallurgists. The coupon is your invitation to use this confidential and obligation-free service.



ALLOY STEEL WELDMENTS meet high strength, precision requirements in USAF bombers. The weldment technique, developed by Rohr Aircraft Corporation, Chula Vista, California, is currently being used in the manufacture of flap tracks for an Air Force Bomber program. The material used is AMS 6428 Alloy Steel, a type supplied by Republic. This fine steel provides a minimum tensile strength of 180,000 psi in the heat treated condition. Uniform response to heat treatment assures exceptionally good deep hardening characteristics — plus hard-wear-resistant surfaces. Specify Republic Alloy Steel for your parts that must be tough, strong, dependable. Our metallurgists will help you. Send coupon for facts.



REPUBLIC DEVELOPS NEW POWDER for structural, electrical, and electronic part applications. Type MS is a soft, higher purity powder with excellent carbon compatibility. It can be used for comparable strength structural parts at lower cost than obtainable with copper. It is also ideally suited for use in fabricating pole pieces, permanent magnets, cores, armatures, etc. MS Powder can be used to fabricate larger parts on normal pressing equipment. Mail coupon for complete details on physical properties, chemical composition, test evaluations.



(Official U.S. Navy Photo)

TITANIUM FOR WEIGHT REDUCTION in the Navy's Vanguard. Because of its weight saving and high strength factors, titanium is currently being used for many applications in both missiles and aircraft. In missiles and rockets it has almost unlimited applications. Titanium's extremely high corrosion-resistance makes it attractive for tanks to hold acids used in combination with missile fuels. Nitric acid, for example, has negligible effect on titanium. It is practically immune to salt water and sea air corrosion. Republic produces titanium in all commercial forms. Republic metallurgists will help you apply titanium to best advantage. Send coupon for more facts.

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World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. ME -6127
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Have a metallurgist call.
☐ Stainless Steel ☐ Alloy Steel ☐ Titanium

Send more information on:
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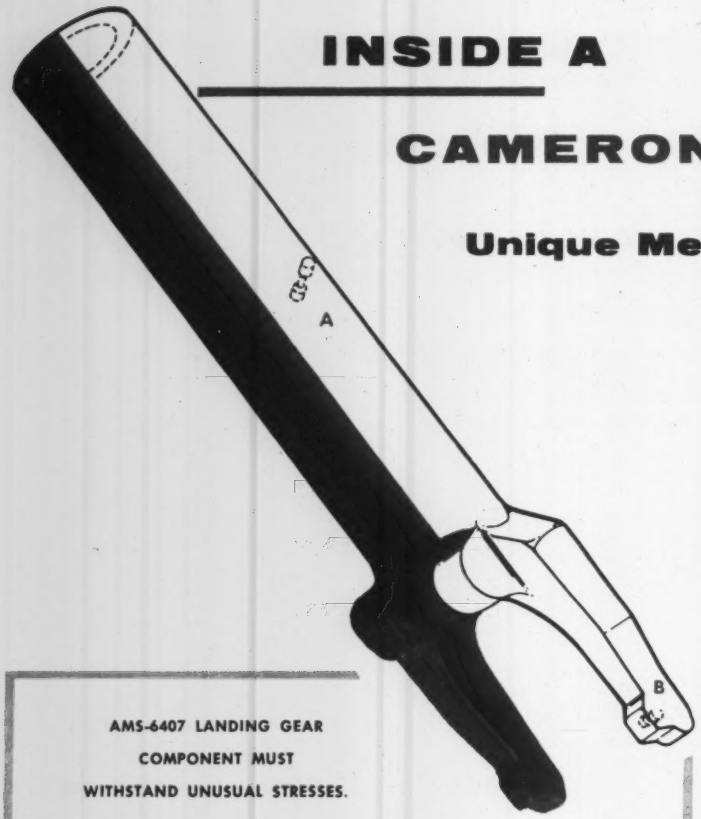
INSIDE A

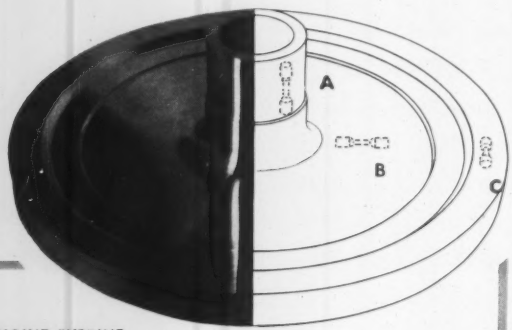
CAMERON FORGING

Unique Metallurgical Properties



AMS-6407 LANDING GEAR COMPONENT MUST WITHSTAND UNUSUAL STRESSES.

		Typical Properties			
		Tensile Strength	Yield Strength	Elongation	Reduction of Area Transverse
A	Tube, Transverse	236,000	203,000	12.7%	45.1%
B	Fork, Transverse	233,000	205,000	10.6%	31.9%



A-286 JET ENGINE TURBINE WHEEL OF SPECIAL ALLOY MEETS UNUSUAL DEMANDS.

		Typical Properties			
		Tensile Strength	Yield Strength .2% Offset	Elongation	Reduction of Area
A	Hub, Longitudinal	158,000	117,000	22.2%	40.0%
B	Web, Radial	159,000	116,000	21.3%	40.0%
C	Rim, Tangential	162,000	117,000	20.3%	39.7%

UNIFORMLY FINE GRAIN SIZE and uniformly high properties from center to surface are characteristic of the Cameron technique. Intricate, unusual, or conventional shapes are produced in a single heat.

INCREASED TRANSVERSE DUCTILITY—several times above normally expected values. Transition from billet to final shape results in movement of metal under high internal pressure.

HIGH ULTRASONIC STANDARDS are consistently met by internal working of the metal which breaks up segregated material inherent in the center of steel and high density alloys.

PARTING LINE PROPERTIES-The totally enclosed method of forging, eliminating a flash line, avoids flash line magnetic indications and the localizing effect of the flash grain on transverse, fatigue, and stress rupture properties.

Extreme service components for airframes, jet engines, guided missiles and a wide variety of other end uses are finding a solution in the Cameron split-die forging process. If you have a problem . . . call, write or come by

Cameron
IRON WORKS, INC.
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

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Helicopter Manufacturer Specifies

Straightening Ostuco Special Quality Tubing to extremely close limits at Shelby mill.

"Our specifications for seamless steel tubing used in rotor drive shafts are tough to meet. In addition to stringent O.D., wall and concentricity tolerances, we require *special straightness* — tube after tube, shipment after shipment.

"Ohio Special Quality Tubing surpasses any other tubing we have ever used. We know this to be fact. Scrap and rejects are at a new low, inspection OK's and savings on this part are at a new high."

This actual case history may parallel your own product problems. For with Ohio Special Quality Tubing it's only the *quality that's special.* For further information contact our nearest sales office, listed in the Yellow Pages, or the plant at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-9011

OSTUCO SHELBY OHIO — OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Washington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburgh, Salt Lake City, Seattle, Tulsa, Wichita · CANADA: Railway & Power Engr. Corp., Ltd. · EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

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from contact shoe beams . . . to ship fenders . . .

GAMBLE solves problems with WOOD!

Contact shoe beams on subway cars hold the apparatus for picking up power from the third rail. The problem: could wood (with its obvious advantages) hold the required dimensional tolerances and provide the necessary dielectric strength? The answer: yes, in the form of a laminated hard maple beam engineered by Gamble Brothers.

The "ship fender" problem was different. Who in the world had the wood-engineering knowledge and physical plant to produce the "king-size" wood laminations? The answer again: Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working on projects in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

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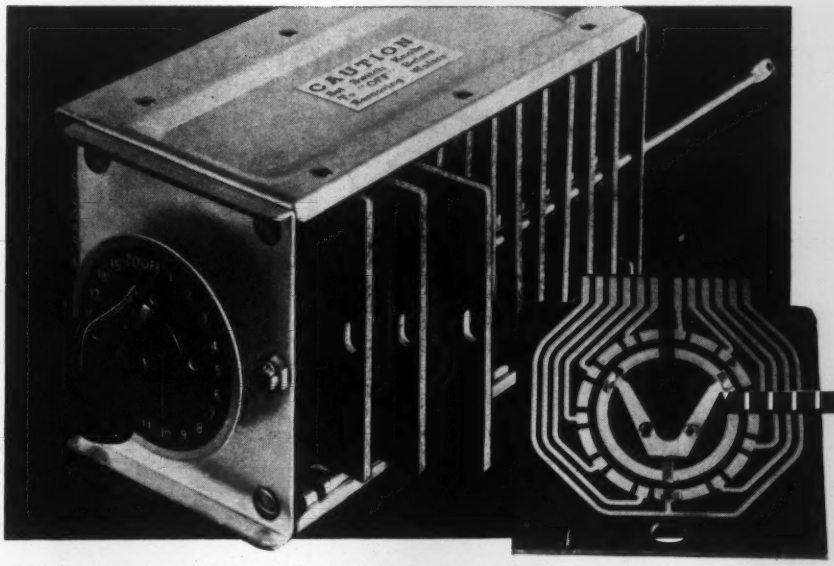

Not hours . . . not days . . . but only minutes is all it takes to change wafers in the new Tabet Rotary Wafer Switch. Wafers, including rotary disc made of Spencer Nylon, plug into semi-floating receptacles . . . are easily removed without unsoldering or tearing down switch.

Rotary disc of Spencer Nylon holds a double arm that makes circuits through the contact segments in this new switch.

Spencer Nylon Chosen For New "Quick-Change" Switch:

Because of its special properties, Spencer Nylon works better than other plastics or metal could in the new Tabet Rotary Wafer Switch!

A revolutionary, new rotary switch now being produced by Tabet Mfg. Co., Inc. of Norfolk, Virginia, makes excellent use of the remarkable properties of Spencer Nylon:

In the center of each snap-out wafer is a rotating disc which must (1) have high resistance to abrasion, (2) be a non-conductor of electricity, and (3) need no lubrication.

Most plastics would be too soft to take the tough abrasive treatment this disc would have to withstand. Insulating a metal disc would be out of the question. And what about the problem of lubrication?

The answer: abrasion-resistant, non-conducting, self-lubricating nylon made by Spencer Chemical Company.

Plastic-light and metal-strong, Spencer Nylon is solving problems for more and more manufacturers every day. So if *you* are faced with a product problem, why not consider the advantages offered by Spencer Nylon?

You may discover that Spencer Nylon not only helps you find the answer, but also helps cut material costs at the same time!

For the names of molders who can supply you with nylon machine parts, gears and bearings, write to Spencer Nylon, Spencer Chemical Company, Dwight Building, Kansas City 5, Mo.

SPENCER NYLON

SPENCER CHEMICAL COMPANY

GENERAL OFFICES, DWIGHT BUILDING, KANSAS CITY 5, MISSOURI

SPENCER®

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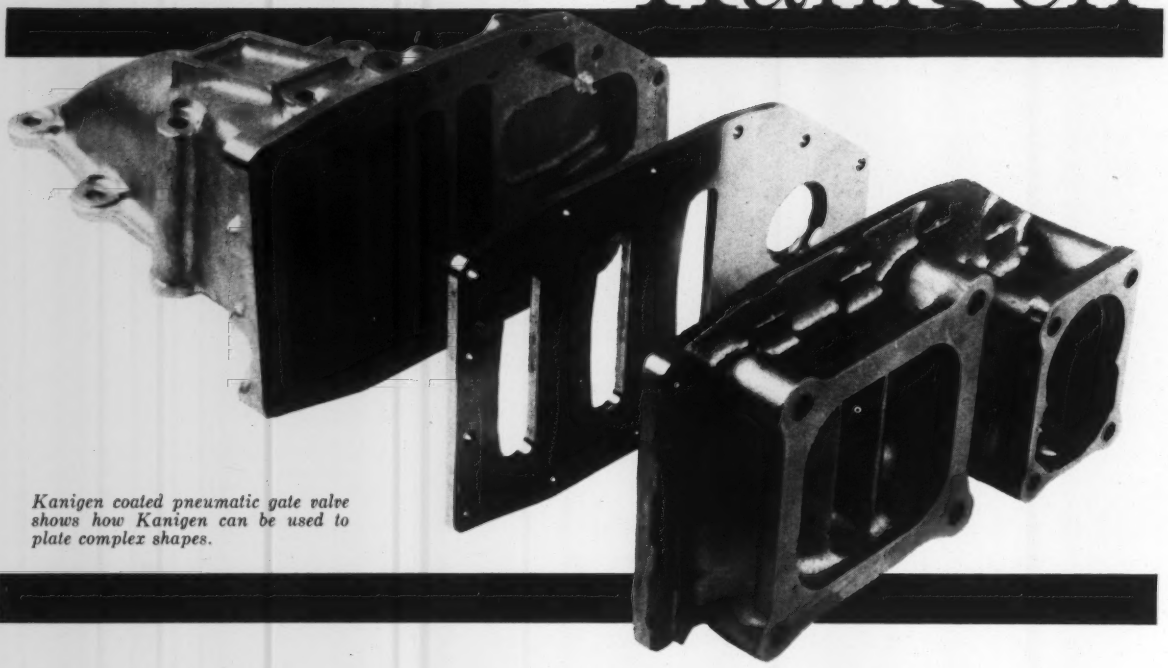
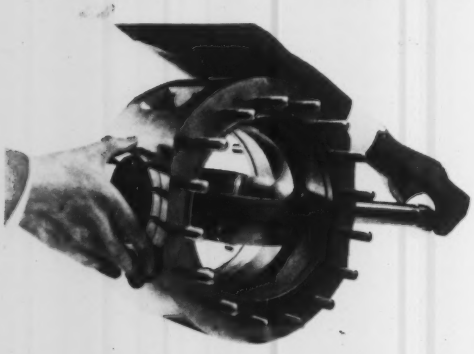
save on materials and labor with Kanigen®



Kanigen coated pneumatic gate valve shows how Kanigen can be used to plate complex shapes.

KANIGEN is a chemically and metallurgically unique process that provides an extremely uniform, hard, corrosion and abrasion-resistant nickel alloy surface on most metals. You obtain practically the same end result with inexpensive, easily machined and fabricated materials that you do with expensive, difficult-to-work alloys. Where weight is a factor, **KANIGEN**-coated aluminum and aluminum alloys offer great advantages.



Butterfly valve assembly, Kanigen-coated for corrosion and abrasion resistance.

General American offers **KANIGEN** at Sharon, Pennsylvania; East Chicago, Indiana, and Compton, California and from licensees. Large production facilities for the plating of **KANIGEN** on iron, aluminum, copper, titanium and their alloys are available. Pilot-scale facilities for plating magnesium, beryllium, uranium, plastics and ceramics are maintained at our laboratory. For further information, call or write. You'll find *it pays to plan with General American.*

KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 90, Illinois

KANIGEN GENERAL AMERICAN TRADE MARK

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BETTER IN MORE WAYS THAN ANY OTHER PLASTIC!

CYCOLAC®

THE TOUGH, HARD *ABS* PLASTIC
***from* BORG-WARNER**

CYCOLAC OFFERS ALL OF THESE ADVANTAGES!

- ★ Superior Impact Strength—even at Low Temperatures
- ★ Rigidity — even at High Temperatures
- ★ Hard, Glossy Surface
- ★ Corrosion, Stain Resistance
- ★ Wide Range of Colors
- ★ Good Electrical Properties
- ★ Dimensional Stability
- ★ Outstanding Performance

Cycolac offers you advantages that cannot be equaled today! Its quality and performance far out-ranges the field. Does your product demand rigidity? Investigate the wall thickness required by other plastics—then compare Cycolac. Must it withstand shock, abuse, rugged use? Do you need sparkling colors and hard glossy surface—corrosion resistance and less overall weight? Cycolac combines *all* of these properties—and more! Before you start a new product or make a design change, look into Cycolac.

CYCOLAC . . . *the NEW dimension in design*
. . . the NEW element in production!

Write for complete technical information!

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Marbon CHEMICAL
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50 *years of results that satisfy just about everybody... except Oakite.* And we never will be satisfied. Our goal has always been to furnish even *better* cleaning at even *lower* cost—AND IT ALWAYS WILL BE!

Sure we're proud of the hundreds of Oakite "firsts" in developing fine cleaning compounds, cost-cutting methods, time-saving mechanical equipment. But we'll never rest on pride. As soon as we find a satisfactory answer to a cleaning problem—our research starts searching for an even better one.

That's why so many users continue to rely on Oakite to reduce their "per unit" cost. They know that year after year, they are getting the best cleaning for the lowest possible cost.

OAKITE

50 1909-1959 SCIENCE

years' leadership in industrial cleaning

Oakite's pioneering in the future will mean what it has meant for the past 50 years: not only better products, but better service . . . better methods . . . better equipment. All deliberately designed with you in mind to give *you* the most for your cleaning dollar.

This handy guide is a distillation of 50 years of Oakite cleaning experience. It can save you valuable time—and cold cash, too—on all your cleaning operations. Send for it. Oakite Products Inc., 50A Rector Street, New York 6, N. Y.

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Bridgeport Ultra Fine Grain Brass Strip Saves Siesta-Ware $2,400 a Year

Colorful Siesta-Ware is designed to create a holiday mood ...and so are the remarkable production savings realized by Benner Glass Company!

Before Benner Glass Company, Jacksonville, Fla., made the happy discovery of Bridgeport Ultra Fine Grain Brass Strip, production of the brass banding on each attractive Siesta-Ware Party Mug, Snack Jar and Tumbler was at the rate of two coils of strip running at 35 lineal fpm through three buffing stages. Today, with Bridgeport UFG Strip, the same machine runs *at the rate of 48 fpm!*

There's a simple reason why Benner Glass now realizes 23% time savings and 8% savings on polishing materials. It is this: the infinitely superior finish of Bridgeport Ultra Fine Grain Strip requires far less buffing. Important savings in time, cutting compound and buffing naturally result. In the annual processing of Bridgeport coiled strip, Benner saves more than $2,400... while turning out an even better finished product!

Don't *you* overlook the sizable savings that can be yours when you switch to Bridgeport Ultra Fine Grain Brass Strip. To get the facts and figures as they apply to your products, call *your* nearby Bridgeport Sales Office... or write direct for a copy of our Ultra Fine Grain Brass Booklet, GRAIN SIZE, THE FOURTH DIMENSION. Dept. 3502.

BRASS Bridgeport CO.

BRIDGEPORT BRASS COMPANY

BRIDGEPORT 2, CONNECTICUT

*Specialists in Metals from **A**luminum to **Z**irconium*

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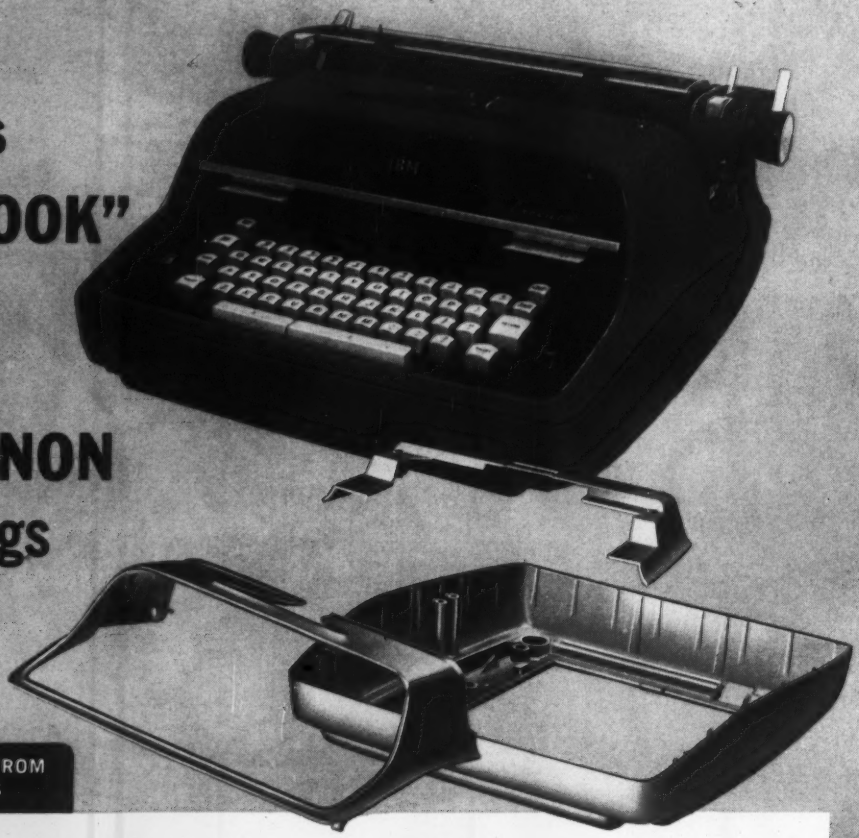
IBM's "NEW LOOK" enhanced with MT. VERNON Die Castings



CASE HISTORIES FROM MT. VERNON FILES

Behind the sleek silhouette of the dramatically new IBM electric typewriters is "more than a quarter of a century of experience . . . a combination of styling and engineering advances" that promise — and deliver — better performance and easier typing.

For its enclosure IBM knew what it wanted: a new high in eye-pleasing design combined with the many low cost, production benefits of die-casting. It was only natural that, for these die castings, once again, they turned to Mt. Vernon, a reliable supplier to IBM for over 25 years.

And, once again, they found Mt. Vernon's co-ordinated four-fold service — designing, die making, casting, and machining—equal to the job of meeting their strict requirements: strong, gracefully arched, thin-walled, large aluminum sections that match and fit perfectly. The three castings that cradle and enclose the intricate typewriter mechanism are delivered completely machined, ready for finishing.

Like IBM, leading manufacturers in all industries know and rely on Mt. Vernon's experienced use of its complete facilities for die cast zinc and aluminum parts ready for assembly. These services, all under one roof in 200,000 square feet of space, may hold the answer to your design and production problems. Think about it . . . and let us know. We'll gladly talk it over, without obligation. Just call your nearest Mt. Vernon sales representative.

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STAMFORD, CONNECTICUT

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Improved performance plus production economies Your job... and Centralab's

with High Alumina Ceramic to Metal Precision Assemblies

Take full advantage of the superior electrical and physical properties of High Alumina and Steatite ceramics. Let CENTRALAB provide you with complete assemblies.

The specialized techniques of close tolerance ceramic-to-metal fabrication are daily routine at CENTRALAB. You can eliminate production assembly problems and at the same time achieve superior products by relying on years of expert knowledge and unequalled facilities for engineering ceramics.

CENTRALAB can handle intricate, precision assemblies involving machining of ceramics or metals to ±.00025, metalizing of ceramics, cementing, riveting, soldering, plating, and stamping. Such assemblies are regularly produced in their entirety—from raw stock—in the CENTRALAB plant.

Write for your free copy of CENTRALAB'S Ceramic Design Handbook giving your detailed design data and complete electrical and physical specifications on High Alumina and Steatite ceramics.

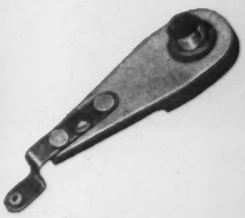
VARIABLE CONDENSER SHAFT
Precision 95% High Alumina shaft and silver plated brass hardware assembled and machined to a Total Indicator Reading requirement of less than .002".

HIGH PRESSURE CONNECTOR
With eight critical metal to ceramic sealing areas, capable of withstanding a minimum of 3,750 psi. Copper plated stainless steel housing.

TUNER COUPLING ARM
To hold center dimensions between riveted brass pivot and cemented phosphor bronze bushing, bushing is machined to a tolerance of ±.0005" or less. O-ring groove on pivot machined to .012" wide, —.000" + .002". Machined ceramic screw.

NON-FLOATING VALVE SEAT
Comprised of ceramic cone with surface finish of 3-5 helium light bands brazed to machined and copper plated bushing. After assembly, Total Indicator Reading of ceramic cone is less than .005".

CONTACT ROTOR ASSEMBLY
With riveted and soldered contact arm. Nickel plated brass bushing soldered to metalized ceramic. Tolerance —.000" + .001". on I.D. of bushing after slotting.



Centralab
X-5939

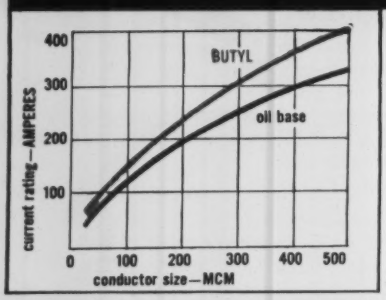
A Division of Globe-Union Inc.
946C E. KEEFE AVE. • MILWAUKEE 1, WIS.
In Canada: 804 Mt. Pleasant Rd., Toronto 12, Ont.

VARIABLE RESISTORS • ELECTRONIC SWITCHES • PACKAGED ELECTRONIC CIRCUITS • CERAMIC CAPACITORS • ENGINEERED CERAMICS

For more information, turn to Reader Service card, circle No. 499

ENJAY BUTYL

BEST WAY TO HANDLE ELECTRICITY



Butyl's outstanding resistance to heat allows considerably higher currents for any given conductor size.

Of all vulcanizable rubbers, Enjay Butyl offers the best electrical and dielectric properties. Butyl is the ideal material for wire and power cable, transformers, tapes, busbars and other insulation applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . abrasion, tear and flexing . . . superior damping properties . . . unmatched impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

For more information, turn to Reader Service card, circle No. 506

Figuring tubing materials on a cost per year basis?

NEW 4-D WROUGHT IRON costs less, lasts longer

The lower the cost per year, the more economical the investment. Especially so when the material lasts a long, long time. Take the cost comparisons below. Based on actual installations, users of wrought iron cold drawn tubing have been investing wisely for many years. Now, with new 4-D Wrought Iron available, your savings are even greater.

Note: New 4-D Wrought Iron was achieved by substantially increasing the deoxidation of the base metal, slightly increasing the phosphorous content and using a more siliceous iron silicate.

Result is *increased* corrosion-resistance, *improved* mechanical and physical properties.

INSTALLATION	COST PER FOOT PER YEAR	
	WROUGHT IRON	STEEL
Hotel, Brooklyn, New York Hot ammonia gas passing through interior of tubes, cooled by salt water circulating along outside of tubes.	$ .03 (19 years)	$ .24 (2 years)
Ice Company, Chicago, Illinois Carbon dioxide condenser service.	.03 (18 years)	.05 (10 years)
Film Corporation, Binghamton, New York Tubes used in cooling service.	.04 (15 years)	.06 (8 years)
Industrial Plant, New Bedford, Massachusetts Ammonia condenser with salt water in coolant.	.04 (12-14 years)	.48 (1 year)
Industrial Plant, Toronto, Canada Tube and shell type condenser used for cooling brine with ammonia.	.01 (50 years)	.07 (7 years)
Ice Company, Aiken, South Carolina Ammonia condensers with mild brine solution containing 76 ppm sodium chloride for cooling.	.03 (18 years)	.29 (2 years)
Ice Company, Rocky Mount, North Carolina Condensers with mild brine solution containing 75 ppm sodium chloride for cooling.	.07 (8 years)	.16 (3 years)
Industrial Plant, Wisconsin Vaporizers for production of butane and propane gas. Severe stresses created by wide temperature variances.	.28 (2 years)	.96 (6 months)
Oil Company, Long Island City, New York Cool, weak ammonia liquor cools hot, concentrated ammonia liquor coming from generator on the way to absorber.	.03 (20 years)	.07 (6-8 years)
Process Company, Detroit, Michigan Heat exchangers with ammoniated brine concentration of about 10% ammonia and salt almost to saturation point.	.08 (8 years)	.16 (3 years)
Gas Company, Brooklyn, New York Ammonia condenser with cooling medium of creek water contaminated by the refuse from several nearby industrial plants.	.05 (16 years)	.22 (3-5 years)
Alkali Company, Saltville, Virginia Heat exchanger carrying ammonia liquor that is subsequently cooled by surrounding water.	.05 (16 years)	.30 (6 mos.-3 years)
Industrial Plant, Chicago, Illinois Condenser tubes in absorption system. Ammonia inside the tubing is about 200°F. and water outside the tubes is about 40°F.	.09 (9-11 years)	.28 (3 years)
Electric Utility Company, Hunts Point, New York Gas cooler drawing water from East River in New York City.	.15 (8-9 years)	.45 (2-3 years)
Warehouse & Cold Storage Corp., Springfield, Massachusetts Ammonia condensers and direct expansion cooling coil.	.02 (30 years)	.04 (12 years)

"Cost per foot per year" figures are calculated from current prices of cold drawn seamless steel tubing (ASTM A-179) and cold drawn wrought iron tubing (ASTM A-382). Because of the many variables involved, costs for installation labor, maintenance and replacement are not included. If they were, wrought iron's low cost story would, of course, be even more impressive.

Details on any of the above installations furnished on request. Write for Wrought Iron Heat Exchanger and Condenser Tubing bulletin.

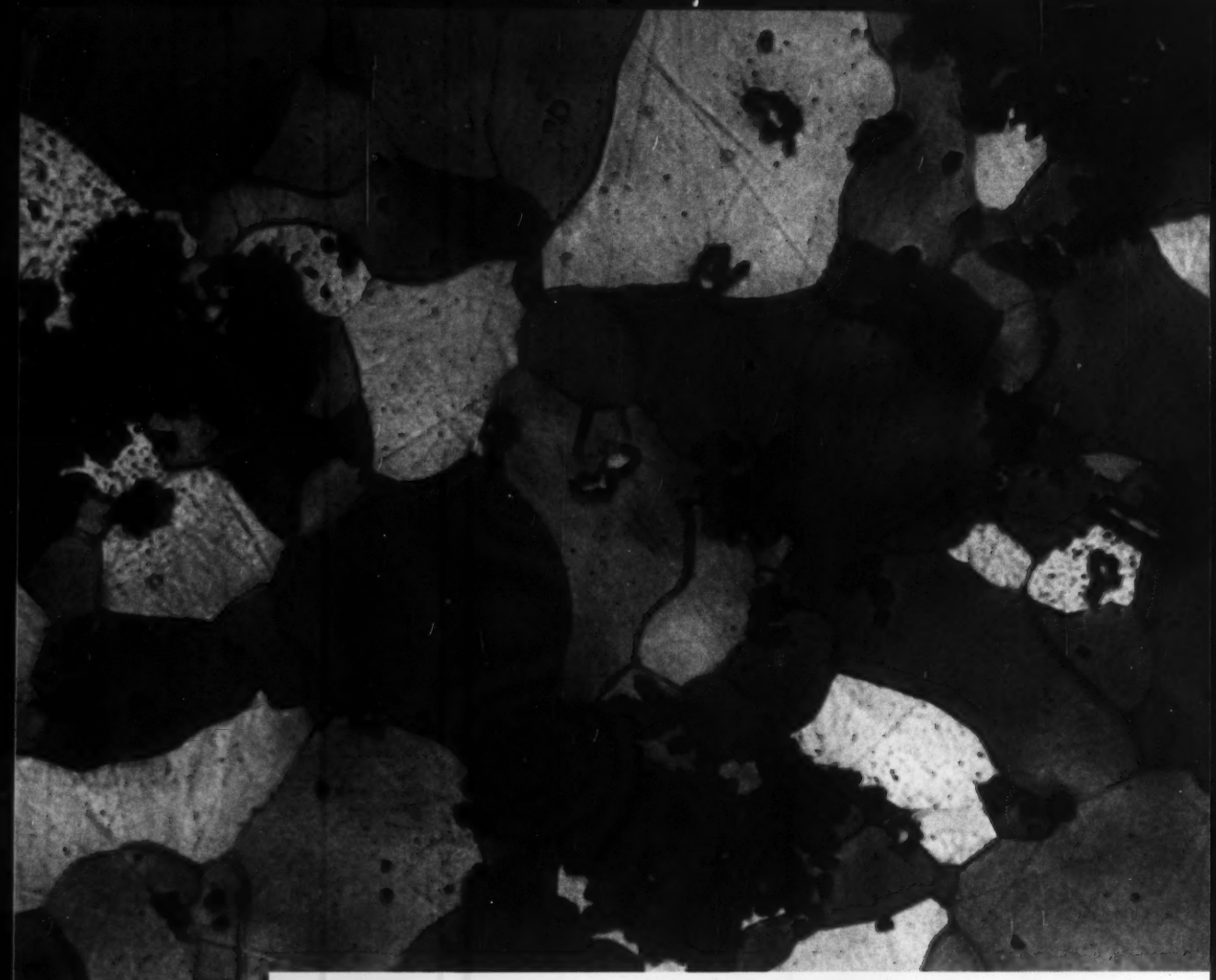
BYERS 4-D WROUGHT IRON

TUBULAR AND FLAT ROLLED PRODUCTS

A. M. BYERS CO., CLARK BLDG., PITTSBURGH 22, PA.

Corrosion costs you more than Wrought Iron

For more information, turn to Reader Service Card, circle No. 396



Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

(Advertisement)

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINEL HARDNESS NO. RANGES

Pearlitic Malleable Irons							
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

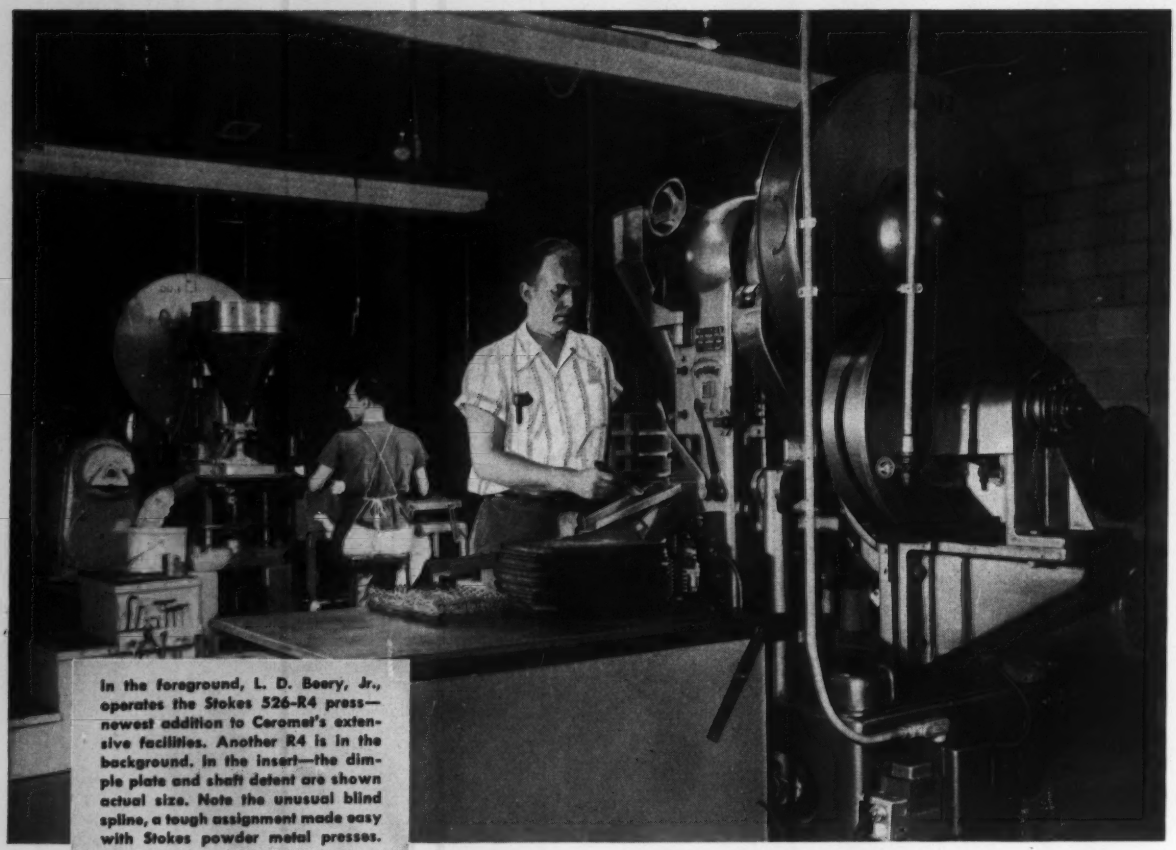
Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

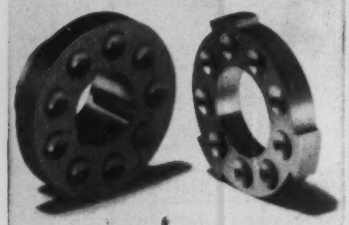
Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**

For more information, turn to Reader Service Card, circle No. 381



In the foreground, L. D. Beery, Jr., operates the Stokes 526-R4 press—newest addition to Ceromet's extensive facilities. Another R4 is in the background. In the insert—the dimple plate and shaft detent are shown actual size. Note the unusual blind spline, a tough assignment made easy with Stokes powder metal presses.



CEROMET INC., cuts precision tool parts costs 60% with STOKES POWDER METAL PRESSES

Ceromet Inc., La Puente, California manufacturer of powdered metal products, makes dimple plates and shaft detents for a major West Coast precision tool company. The combination of sintered metal and Stokes compacting presses were chosen for this job to provide fast, economical production of quality, close-tolerance parts. Both pieces are produced at the rate of 25 per minute, sintered in a dissociated ammonia atmosphere, and case hardened .020" in a carbo-nitriding furnace.

Stokes industrial compacting presses produce these parts at an estimated 60% cost reduction over machining—make possible the production of efficient designs not even possible by older and costlier methods. The reproducibility of dimensional control is within 1%—thanks to powder metallurgy techniques and Stokes precision equipment.

Stokes Engineering Advisory Service will be glad to consult on your specific powder metal applications—to help design parts, punches and dies, or complete production facilities. Additional technical information on the entire Stokes line of industrial compacting presses will be sent you on request.

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service Card, circle No. 374

Developed by Du Pont research

NEW FAIRPRENE® DIAPHRAGM MATERIAL

demonstrates outstanding resistance to "sour gas," ozone and aromatic fuels

Du Pont research has developed an outstanding "Fairprene"† coated fabric for diaphrams in fuel pumps and carburetors. This new "Fairprene" shows remarkable resistance to the effects of oxydized gasoline, or "sour gas," and ozone. It is exceptionally resistant to swelling in contact with highly aromatic fuels. In addition, this new "Fairprene" coated fabric shows superior abrasion resistance and retains its properties to -65°F.

New "Fairprene" ozone and fuel-resistant coated fabric is offered in widths to 41" and thicknesses from 0.004" to 0.050", with cotton, rayon or nylon fabric inserts. Mail coupon or write for your free sample plus complete specifications and prices. E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division MDE-93, Wilmington 98, Delaware.

CONSTRUCTIONAL AND PHYSICAL PROPERTIES††

Quality No. FABRIC BASE	22-005FO NYLON	21-009FO COTTON	22-006FO NYLON
Thickness	.013"	.013"	.050"
Tensile Strength—Lbs./Inch, Min.	75 x 75	80 x 80	300+ x 300+
Tear Strength—Lbs., Trap., Min.	2 x 2	2 x 2	25 x 25
Burst Strength—PSI, Mullens, Min.	125	125	500
Ozone Resistance at 60 Parts Per Million*	OK 208 Hr.	OK 208 Hr.	OK 208 Hr.
Fuel Resistance—Volume Change after 72 Hrs. at Room Temp. in ASTM High Aromatic Fuel**	+3.3%	+9.4%	+20.9%

*Ordinary diaphragm materials fail in 15 minutes under this test.
**Ordinary diaphragm materials swell about 20% under the same conditions.
††The above data are based upon tests on production experience and should not be used as specifications.

†*"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements*

DU PONT
INDUSTRIAL COATED FABRICS
SHEET STOCKS · CEMENTS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

▶ Mail coupon for free sample of new "Fairprene" ozone and aromatic fuel-resistant diaphragm material . . .

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. MDE-93, Wilmington 98, Delaware
☐ Please send free sample of new "Fairprene" diaphragm material with high ozone and aromatic-fuel resistance.
☐ Please send bulletin on "Fairprene" industrial coated fabrics.

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 477

Greater latitude in radio cabinet design is permitted by the higher heat resistance of CYMAC® 400 polymethylstyrene plastic which will withstand continuous service at temperatures to 212°F without distortion. This property, plus its ready adaptability to complex molding and its excellent flow and color characteristics, was one of the reasons it was selected for the cabinet of the RCA Victor table radio, *The Burgess,* illustrated here.

Additional advantage of CYMAC is that it has sufficient flexibility for back cover to be secured without fasteners: a simple snap-fit reduces cost, speeds assembly, and facilitates disassembly if required. The following properties indicate CYMAC 400 is an ideal material for radio cabinets and similar housing requirements:

Resistance to heat, °F (cont.)	212
Heat distortion temperature, °F	213
Molding shrinkage, in./in.	.0046
Specific gravity	1.02
Flexural strength (1 in./min crosshead speed)	12,500
Impact strength ft/lb/in. of notch (½ x ½ in. notched bar, Izod Test)	.30
Rockwell hardness	76M
Dielectric strength, short time, ⅛ in. thick volts/mil, 1/16 in. disc	890

CYANAMID

PLASTICS NEWSFRONT

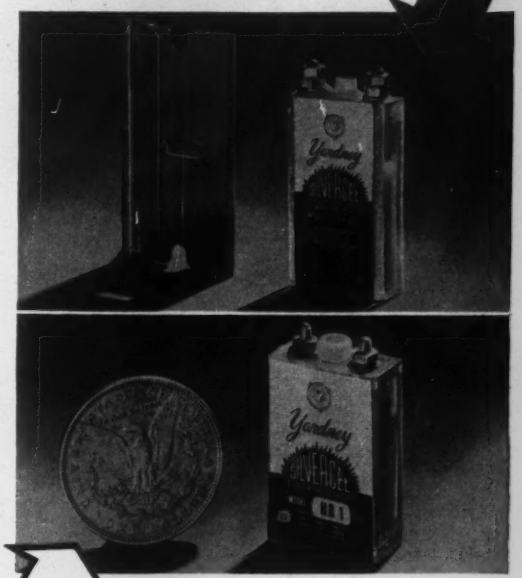
New ideas in product design and application of Cyanamid plastics.

Plastic materials and production methods behind successful products.

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
34M Rockefeller Plaza, New York 20, New York

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices in: Charlotte • Chicago • Cincinnati • Cleveland • Dallas
Detroit • Los Angeles • Minneapolis • New York • Oakland
Philadelphia • St. Louis • Seattle

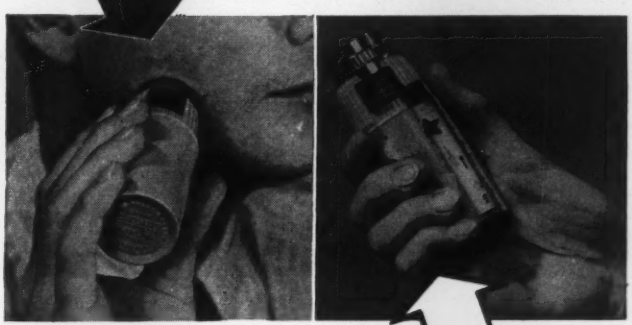
World's smallest and lightest rechargeable battery cell, shown here with razor blade, is Yardney Electric Corporation's HRO1 Silvercel®. Designed primarily for use in instrumentation and telemetering packages for missiles and rockets, it has a 3 amp peak pulse discharge and weighs less than one-seventh ounce — thanks in great part to lightweight molded CYMAC SUPER® 201 thermoplastic case and cover.
®Trade mark



Another Yardney silver-zinc cell is shown here with a silver dollar for size comparison. This HR1 Silvercel® delivers a 45 amp peak pulse discharge yet weighs only ¾ ounce. CYMAC SUPER 201 methylstyrene-acrylonitrile copolymer was selected because of its:

- Low specific gravity (1.06)
- Exceptional combination of high tensile (11,000 psi) and high flexural (16,100 psi) strengths
- Heat resistance (distortion point 211°F)
- Complete resistance to concentrated potassium hydroxide electrolyte
- Excellent injection molding characteristics, transparence, resistance to crazing, and ease of solvent-sealing covers to cases.

New cordless electric shaver features light weight (two ounces), damage-resistant case of CYMEL® melamine plastic, designed by Raymond Loewy Associates. This smart-looking Universal shaver operates anywhere on ordinary penlight or transistor batteries. The CYMEL case is contoured to fit the hand, corrugated at the top for a natural, easy grip.



Battery and motor unit are secured by light press fit in housing compression-molded of CYMEL 1079 melamine molding compound. CYMEL resists breaking, chipping, scratching, perspiration, and corrosion from shaving lotions and battery chemicals. It provides a rich look and warm feel. Color, molded in, can't chip or wear off. Molded by Holyoke Plastics Company, Holyoke, Mass., for Landers, Frary & Clark, New Britain, Connecticut.

For more complete information on these and other Cyanamid Plastics, send for the latest copy of our catalog, *"Molding Compounds and Resins."*

New polyester resin from Cyanamid
LAMINAC® Resin 4106 for dual-spray applications

Cyanamid's new polyester resin, LAMINAC 4106, is rigid in type, with medium reactivity and low thixotropic viscosity. It is made especially for application by dual-spray methods. When so used, the resin is divided into two portions, one containing catalyst, the other promoter, both of which are stable until mixed as converging streams enter the mold. Low viscosity and slightly thixotropic characteristics promote rapid wetting of glass fibers and freedom from sagging on vertical molded surfaces. Cure is rapid, permitting production of multiple parts per day from a single mold.

TYPICAL CHARACTERISTICS-LAMINAC 4106

Viscosity*	5 poises
Specific gravity	1.1
SPI cure characteristics	
Gel time	3½ minutes
Time to peak temperature	5½ minutes
Peak exotherm temperature	400°F

*Brookfield Model RVF, spindle #1, 10 rpm 77°F

For more information, turn to Reader Service card, circle No. 436

DOW | MAGNESIUM

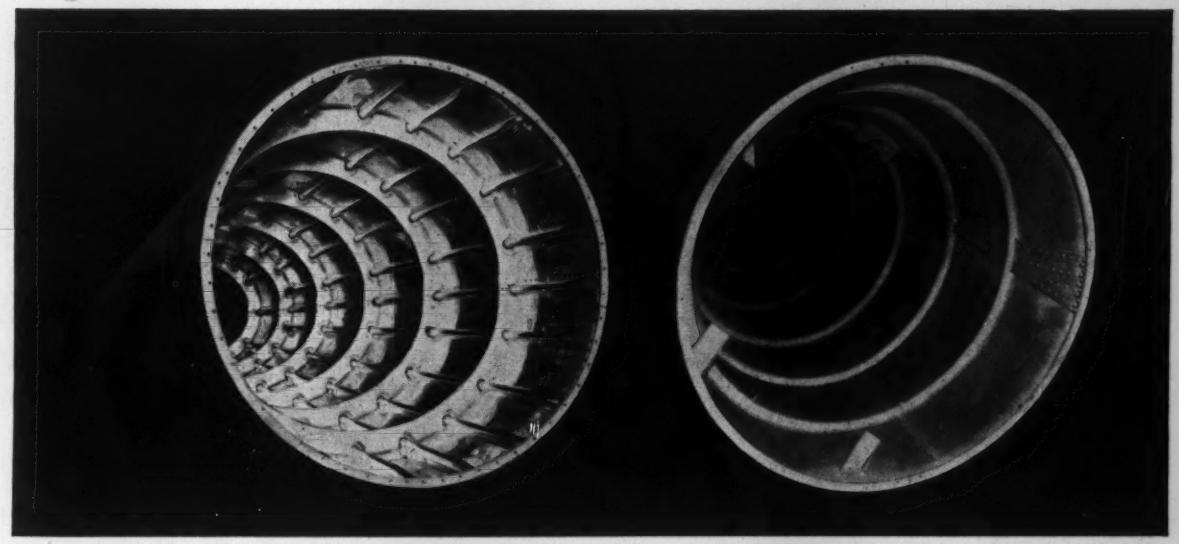
LIGHTWEIGHT DESIGNS

save more than weight

Designers reap a rich harvest of additional benefits as a result of lightness when they use magnesium. Bonuses such as more payload, simplified design, increased performance and reduced human exertion.

People who buy and use the luggage pictured above derive a very direct benefit from magnesium. As this lightweight luggage is made of magnesium, it saves human effort and fatigue. Also, the reduction of weight means more luggage can be carried without extra charge when traveling by air. Magnesium saves human exertion in other products, such as ladders, power tool housings and materials handling equipment.

Another example of the many savings and extra benefits that magnesium —and its resultant load lightening make possible for the designer is in the automotive field. One delivery truck unloads its last parcel and heads for the garage and the gas pump. Another, of identical size, goes on to deliver many



SIMPLIFIED DESIGN in magnesium aircraft part (right) was made possible by its advantageous stiffness-to-weight ratio.

more lbs. of merchandise. Why? The second truck is much lighter—its body is made entirely of magnesium alloy sheet, plate and extrusions. *Because* the second truck is lightweight, it can carry more payload. Or, it can carry the same payload as the first with less fuel, smaller tires and less wear and tear on the engine and transmission. Lighter trucks also save their owners money on license fees, insurance premiums and over-all maintenance.

An even more dramatic example is that of missile design. In one ballistic missile, the elimination of *one pound* of excess weight contributes approximately 18,000 feet of additional altitude and a comparable increase in range! This means vastly improved performance wherever magnesium can be substituted for heavier materials.

MAGNESIUM LIGHTNESS INCREASES STRENGTH, STIFFNESS

The designer who is seeking a stiff section can achieve it easily—and still save weight—with magnesium alloys. Magnesium weighs only 67% as much as aluminum, 25% as much as steel and zinc. A structure made of magnesium could be 8 times as stiff as the same part in steel if designed to equal weight. If equal stiffness is the design criterion, a magnesium section can weigh 62% less than steel and 25% less than aluminum.

Aircraft manufacturers have learned to exploit these facts to the fullest in conserving precious airborne weight. Critical parts such as wing and tail structures can be designed with more than adequate stiffness for high speed flying conditions. And, in addition to weight savings, magnesium helps provide a smooth aerodynamic surface and reduces "flutter" and "drag". Most important, the use of more rigid magnesium sections simplifies design by eliminating many of the stringers and stiffeners necessary with other materials.

★ ★ ★

WRITE TODAY for new brochure, "Magnesium Design". For your copy of this valuable reference for designers, contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Sales Department 1340 CD 3.

22,000 r.p.m. HOUSEHOLD ITEM

This die cast vacuum cleaner fan must rotate at 22,000 r.p.m. and have low starting inertia as well as high centrifugal strength. Only magnesium was able to meet the requirements of this specific design. Casting tolerances are held so closely there is no need for balancing.

WORKER FATIGUE THWARTED

A prominent automotive manufacturer uses magnesium paint shields in spraying speedometer panels. The weight saving compared to previous shields resulted in less fatigue, higher efficiency for women employees. The excellent alkali resistance of magnesium permits easy removal of dried paint.

PRODUCTION FACILITIES

Excellent production facilities, maintained by Dow and other manufacturers, are located throughout the nation. These firms are well equipped to provide castings, mill products, fabrications and related production services which effectively utilize magnesium's inherent advantages.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

For more information, turn to Reader Service Card, circle No. 395

CHOOSE FROM 100 RARE EARTH SALTS

One of them may offer you unexpected and profitable advantages

a report by LINDSAY

The unique properties, intriguing characteristics and amazing versatility of the rare earths suggest the possibility of their usefulness to you. It's not unlikely when you consider that rare earth salts are being used today in production processes involving glass, metals, ceramics, chemicals, fabrics, paint and pharmaceuticals, just to name a few.

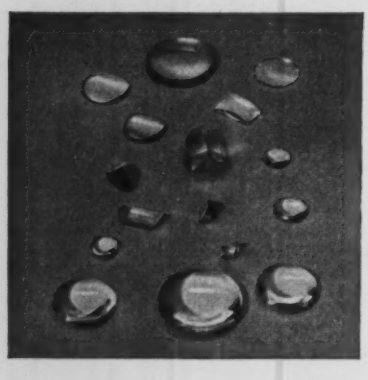
Even today, some manufacturers have not investigated the rare earths because they still think they are *rare*. That is not so. Only a few years ago, the rare earths were little more than laboratory oddities, except of course for a few well-known basic and critically important applications.

It will interest you to know that we are producing more than 100 rare earth, yttrium and thorium salts. We can make prompt shipments in commercial quantities. And at extremely favorable prices.

If you are concerned with research, product development or production processes, it will be significant to you that there has been a vast change in rare earth production during the past ten years . . . in volume, in varieties, in purities of materials commercially available, and in prices.

This is the result primarily of two factors. The curiosity and imagination of research workers who have developed many practical applications. And our own enormously expanded production, particularly of rare earths in high purities up to 99.99%.

Look with us for a moment at some of the interesting developments.



Glass polishing with cerium oxide is one of the most extensive rare earth applications. Lindsay, nearly 20 years ago, revolutionized glass polishing practices in this country when it introduced cerium oxide. Today it is used for polishing millions of spectacles, lenses for cameras and other high precision optical instruments, TV picture tubes, fine quality mirrors, automobile windshields and many glass specialties.

We are operating a fully equipped and capably staffed polishing laboratory continually working on quality control and evaluation of new formulas. If you have a polishing problem, you may find it fruitful to talk with us.

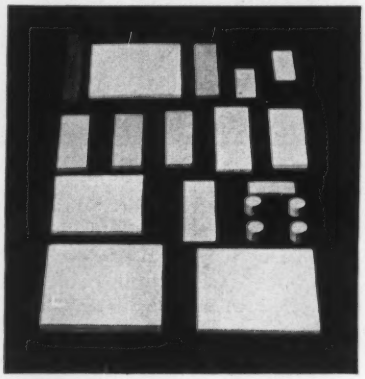
Rare earth garnets for electronic equipment are structurally somewhat similar to the garnet variety grossularite (formula $Ca_3Al_2(SiO_4)_3$). The most interesting ones are the rare earth-iron garnets such as $Y_3Fe_2(FeO_4)_3$. This mouthful of formula has been abbreviated by researchers to "YIG" for obvious reasons. Other names stem from other rare-earth symbols. These garnets, particularly those of yttrium, gadolinium, erbium, and some others have interesting ferrimagnetic properties, making them useful as ferrite materials in electronic equipment.

We don't make the garnets but we can supply the correct material for this particular application, and, of course, helpful technical service.

Neutron absorbing rare earths are now available in ample quantities and at reasonable costs for use as poisons in nuclear reactors. Europium is the most effective control rod material but is relatively scarce and expensive. Control rod designers are making progress in demonstrating the desirable performance characteristics of gadolinium, dysprosium, samarium and erbium.

We would be happy to supply to qualified persons information about significant developments in this field.

Sintered shapes. Through our laboratory research, we have developed a process for producing rare earth oxides in sintered shapes. This information is



now available to you if your experimental work indicates this a desirable form of the rare earth oxides.

Rare earth and yttrium metals are now available from Lindsay. Many users of rare earths prefer them in this form. Our high purity rare earth metals are furnished primarily in the form of ingots or lumps. They are available for prompt shipment from our inventory in experimental quantities.

You will find costs reasonable and advantageous for your research or product development and production operations. Want more information?

This report indicates a wide range of commercial interest in the rare earths. Certainly they have a quite remarkable flexibility and versatility in their application to many uses.

We can't tell you how to use the rare earths in your processes. But we can offer you technical data which may be of interest to your research people.

Please tell us your area of potential interest and we'll try to supply information which is most helpful to you.

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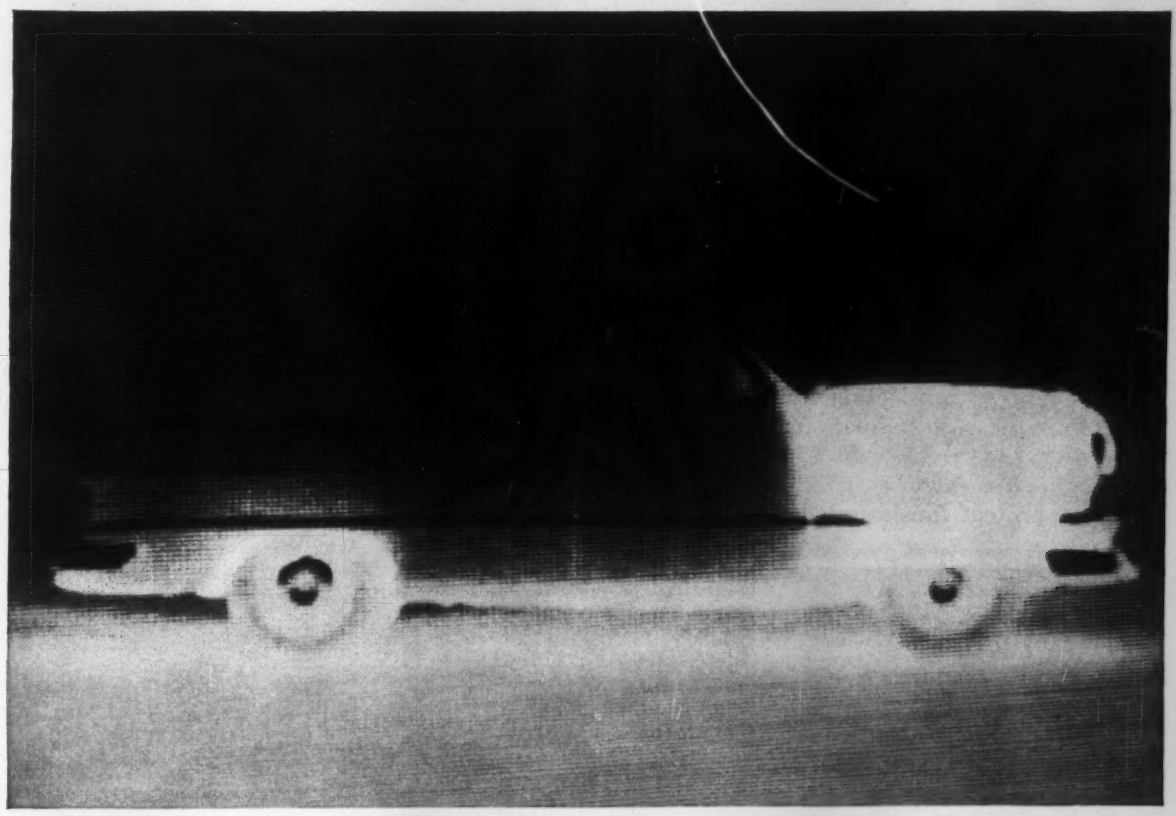

Thermal photography has many applications to industrial problems involving study of temperature distribution over large or small areas. Camera is produced by Barnes Engineering Company, Stamford, Conn.

New infrared camera gives designers...

a candid picture of heat

Here's a car with its motor running — as seen by an electronic thermal camera.

Look at this not so much as a picture of an automobile but as a picture of *heat*. For that's what it is — a candid shot telling the trained eye exactly *where, how* and *how much* heat is distributed about engine, body and chassis.

Thermal camera photographs give engineers an important new tool for evaluating designs. Of many kinds. In many fields.

How thermal camera works. All warm objects radiate infrared energy. A "detector" inside the camera converts this heat radiation into an electrical signal. It is amplified by tubes containing Nickel... processed ...pictured on film. Cool areas appear black; higher temperatures show up lighter.

The detector, more than any other single component, determines the capabilities of the camera. The ideal detector has high sensitivity ... low electrical noise level...fast response.

Extremely efficient. The infrared detector is made of a thin flake of semiconductor material composed of Nickel and other oxides called a "Thermistor". This type of semiconductor was originated by the Bell Telephone Laboratories. These oxides absorb infrared rays and the resulting minute change in temperature causes an appreciable change in electrical resistance. Sensitivity is further increased by forming the flake razor-edge thin. (And even then, platinum contact wires are readily bonded to it!)

The use of Nickel in the infrared detector is another example of the efficiency and adaptability of this important element. Be sure to investigate Nickel compounds and Nickel alloys whenever you are faced with a problem calling for unusual electrical or electronic properties ... or when you need one with superior ability to withstand destructive service conditions. And don't hesitate to call on Inco for any technical data or other help you need.

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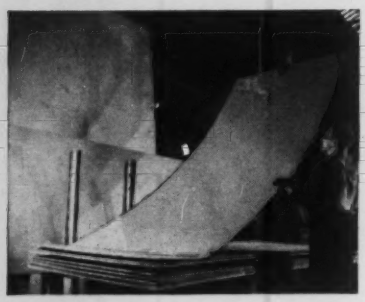
STAINLESS DIRECTORY

Buyers Guide to Ryerson Stainless Stocks & Services

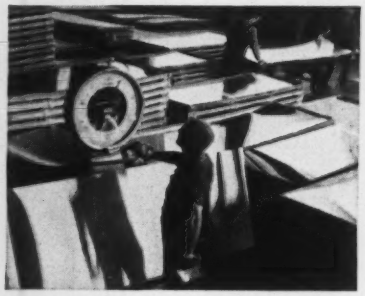
Here's a quick guide to the nation's largest stocks of stainless steel—2,351 sizes, shapes, types and finishes of stainless in stock at Ryerson.

This wide selection assures you of getting the best stainless for every application. Extra care in storage, handling and shipping—such as padded shear clamps to protect finish and flatness of sheets, guards the high quality of Ryerson stainless stocks. And in addition, the help of full-time stainless specialists is yours when you call Ryerson.

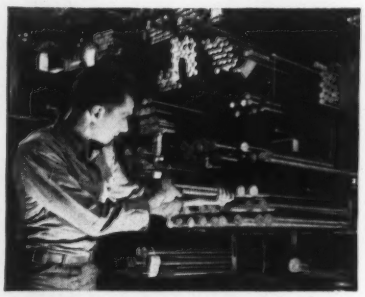
See your Ryerson catalog for a complete listing of stocks and call your nearby Ryerson plant for quick shipment of stainless—any type or size—one piece or a truckload.



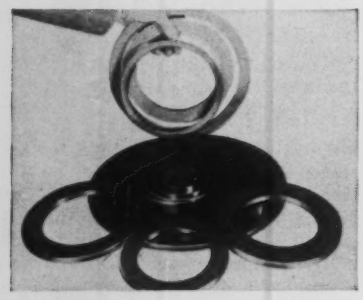
PLATES—Available in 9 analyses including plates to Atomic Energy Commission requirements and to ASTM specifications for code work. Also low carbon types for easy welding.



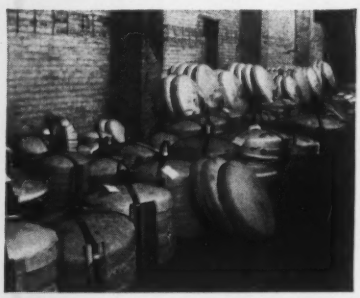
SHEETS—11 analyses of Allegheny stainless sheets in stock including nickel and straight chrome types. Also extra wide sheets to reduce welding costs, expanded and perforated sheets.



BARS AND ANGLES—Rounds, squares, flat's, hex's and angles in 8 types including free-machining bars with both analysis and mechanical properties controlled.



RINGS AND DISCS—Machine cut to your order. This service assures size accuracy, smooth edges, flatness and unaffected corrosion resistance in a lower-cost, ready-to-use product.



HEADS—A.S.M.E. flanged and dished heads in types 304, 304L, 316 and 316L are on hand in large quantities, and in a wide range of gauges and sizes.

PIPE AND TUBING—Light wall, standard and extra heavy pipe, ornamental and regular stainless tubing. Also screwed type and welding fittings and Cooper stainless valves.

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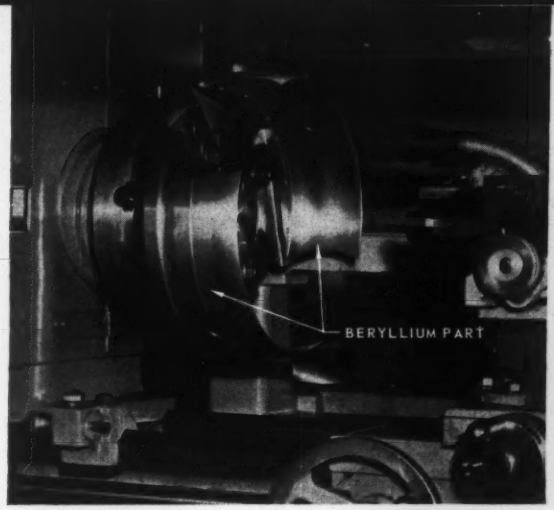
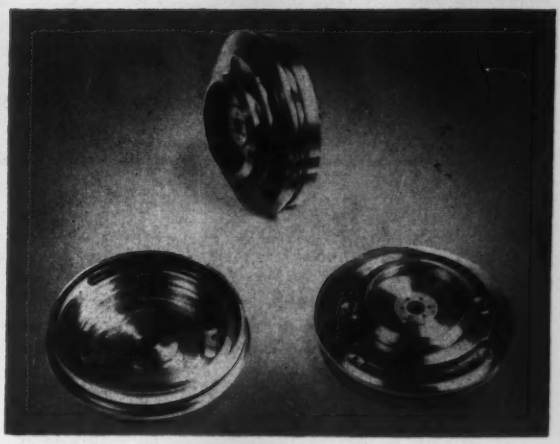
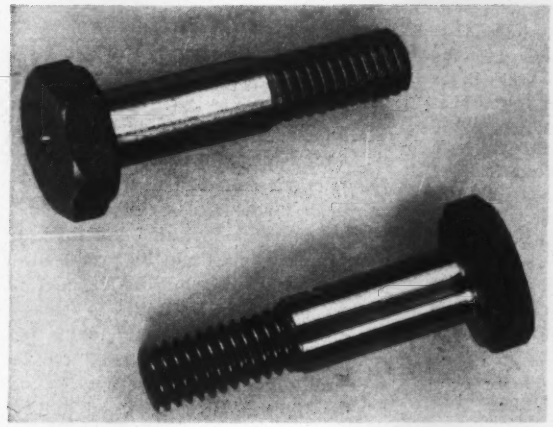


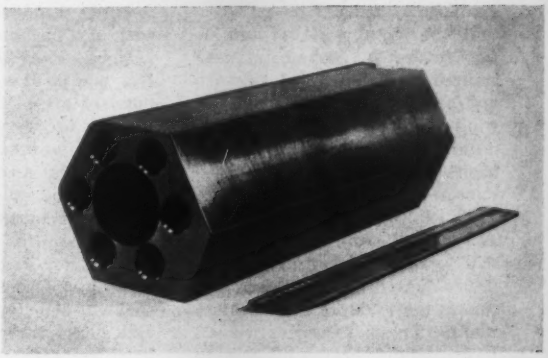
Gyro part *is machined by conventional procedure except that special hood is used to remove toxic dust particles and fumes.*



Small complex parts *were machined from beryllium. Note the excellent surface finish obtainable.*



Fasteners *were blanked, hot forged, machined, centerless ground and roll-threaded.*



Reactor part *was milled and drilled using ordinary procedures.*

Beryllium

A New Engineering Metal

First practical report on its properties, fabrication and uses

by J. W. F. Blizard, Jr., *Production Design Engineer, and* **Frank A. Twitchell,** *Senior Production Design Engineer, Norair, Northrop Corp.*

■ Interest in beryllium as a structural material arises from its light weight, its high modulus of elasticity, its good elevated temperature properties and its corrosion resistance. However, development has been hampered by the low ductility and availability of the metal.

Beryllium is currently used in nuclear reactors, an application in which ductility is no problem. The metal is also being used in certain aircraft components in spite of its low ductility.

At present price is also a limiting factor. It varies from $50 to $200 per lb depending on the form. Fabricated billets vary from $90 to $125 per lb.

Properties

Beryllium is nearly as light as magnesium, has an electrical conductivity about 40% of that of copper, and has a melting point about twice that of aluminum. Some specific physical properties are given in Table 1.

The mechanical properties of

beryllium are strongly influenced by the method of preparation. Depending on the production method, tensile strength varies from 33,000 to 110,000 psi, and there is a corresponding variation in yield strength. Ductility, as measured by elongation and reduction of area, is rather low. However, there is no fundamental reason for this low ductility and it is probable that beryllium, like some of the other new metals, will show much greater ductility when greater purity is achieved. Mechanical properties are given in Table 2.

As shown in the graph on the next page, beryllium retains its short-time strength to moderately elevated temperatures. Ductility increases as temperature increases up to about 800 F, but falls again at higher temperatures.

Beryllium requires no protection from atmospheric oxidation at temperatures below 800 F, but the surface must be protected at higher temperatures.

Forming

Beryllium parts are generally fabricated from hot pressed billets produced by powder metallurgy but some parts can be made from vacuum cast metal. Forgings, extrusions and rolled sections have been made successfully.

Sound beryllium forgings of simple shapes can be produced at temperatures ranging from 1500 to 2000 F if the billet is encased in steel to prevent oxidation. Sharp contours should be avoided and dimensional tolerances must be liberal. Dies designed to keep the metal under compression yield the best results.

Bars, tubes, and simple shapes can be extruded, and this method offers promise for production operations. Although billet temperatures as low as 800 F have been used, greater success is achieved by extruding at 1800 F. At the latter temperature, an extrusion ratio of 16:1 is practical. The beryllium billet must be protected from oxidation by jacketing with steel.

Rolling of steel-jacketed billets at 1340 to 1470 F (just above the recrystallization temperature) minimizes grain growth and permits reductions up to 80% without cracking. Foil as thin as 0.002 in. has been produced.

Joining

Welding, brazing and soldering of beryllium are still largely in the experimental stage, although special techniques produce satis-

Uses of Beryllium

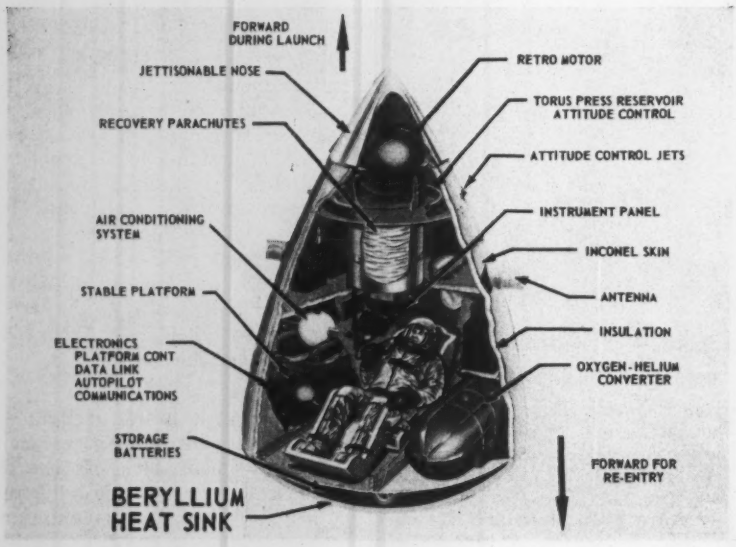
Major use of beryllium at present is in nuclear energy projects in which ductility is not a problem. The AEC is employing the metal as a neutron reflector and moderator in atomic piles because of its strength and low energy absorption characteristics.

In spite of the ductility problem, beryllium is now used in the aircraft industry for servomechanism gears and parts in guidance systems. It is expected that the metal will be used in the future in certain critical structural members of aircraft and/or space vehicles and in wing surface areas requiring minimum weight at especially high temperatures. It is also expected that portions of aircraft exposed to jet flames, such as the intake and exhaust tubes, will be made of beryllium.

Production of beryllium fasteners is an important development. These fasteners should have definite uses in joining critical aircraft parts that are exposed to elevated temperatures.

Outside of these two fields, the most important use of beryllium is for windows in x-ray machines, since the metal has good transparency to x-radiation.

A potential application of beryllium is in a man-carrying satellite. A major problem to be overcome is the dissipation of heat. Assuming the most severe re-entry condition — the flight path of a meteor—the total heat to be dissipated is roughly 9880 Btu per lb of vehicle. At high temperatures, sublimation of beryllia occurs with an absorption of approximately 10,600 Btu per lb. Assuming that half of the energy of re-entry is dissipated to the air, a 100-lb vehicle requires about 46.5 lb of beryllia for successful re-entry. This is one basis for the selection of beryllium as the heat sink in Northrop's proposed ballistic recovery capsule.



Manned satellite *proposed for space exploration.*

TABLE 1—PHYSICAL PROPERTIES

Density, lb/cu in.	0.067
Melting Point, F	2345
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	92
Coef of Ther Exp (68-1300 F), per °F	9.9 x 10^{-6}
Specific Heat, Btu/lb/°F	0.43-0.52
Electrical Resistivity, microhm-cm	3.9-4.3
Magnetic Susceptibility, gauss/oersted	0.79

TABLE 2—MECHANICAL PROPERTIES

Condition →	Warm Extruded	Warm Extruded, Annealed	Hot Extruded	Hot Pressed
Mod of Elast in Tension, psi	—	—	—	44 x 10^6
Ten Str, 1000 psi	85-110	70-100	70-90	33-51
Yld Str (0.2% offset), 1000 psi	82-95	45-65	33-50	27-33
Elongation, %	0-1	2-10	5-25	1-4
Red. of Area, %	—	—	—	1-3
Compr Yld Str (0.2% offset), 1000 psi	85-90	50-60	35-50	25-30
Shear Yld Str (0.2% offset), 1000 psi	30-35	18-20	14-16	15-17
Mod of Elast in Torsion, psi	—	—	—	22.5 x 10^6
Poisson's Ratio	0.03	0.03	0.032	0.024

factory joints.

For example, sound welds have been made by taking advantage of the differences in expansion of beryllium and graphite to produce pressure at the welding temperature. Beryllium sheets are overlapped and packed with graphite in a confined area. At temperatures near 2000 F, sufficient pressure can be developed for fusion. An inert atmosphere must be used to protect the weld area from contamination and resulting embrittlement.

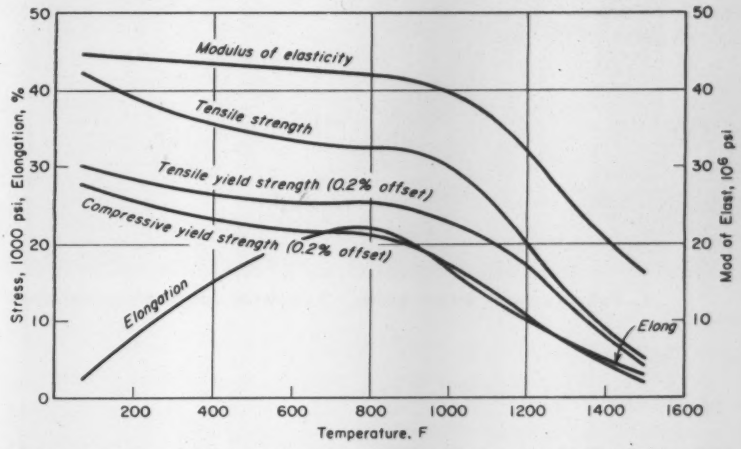
Furnace brazing with aluminum or aluminum alloy foils can be performed successfully at 1400 to 1600 F in an argon atmosphere. Roll brazing with the same filler metal has been accomplished with considerable rolling reduction.

Soldering can be performed by conventional techniques after coating the beryllium surface with copper; the area to be soldered is painted with copper chloride dissolved in turpentine and heated to 800 F to reduce the chloride and obtain a copper deposit.

Machining and grinding

Beryllium can be machined with conventional tools but special hoods, suction vents and shields are essential to prevent contact with the fumes or dust particles because of the toxicity of the metal. The metal is unusually prone to cracking during machining.

Either high speed steel or carbide tools can be used in turning beryllium with speeds and feeds similar to those used for cast iron. Extremely fine and heavy feeds should be avoided: fine feeds tend to overheat the work; heavy feeds cause poor surface finish. Beryllium can be threaded in a lathe, preferably using single-point tools instead of dies.



***Hot strength**—Beryllium retains its strength to moderately high temperatures.*

Milling follows the practices used in turning. Conventional, rather than climb, milling should be used to obtain the best surface finish with good tool life.

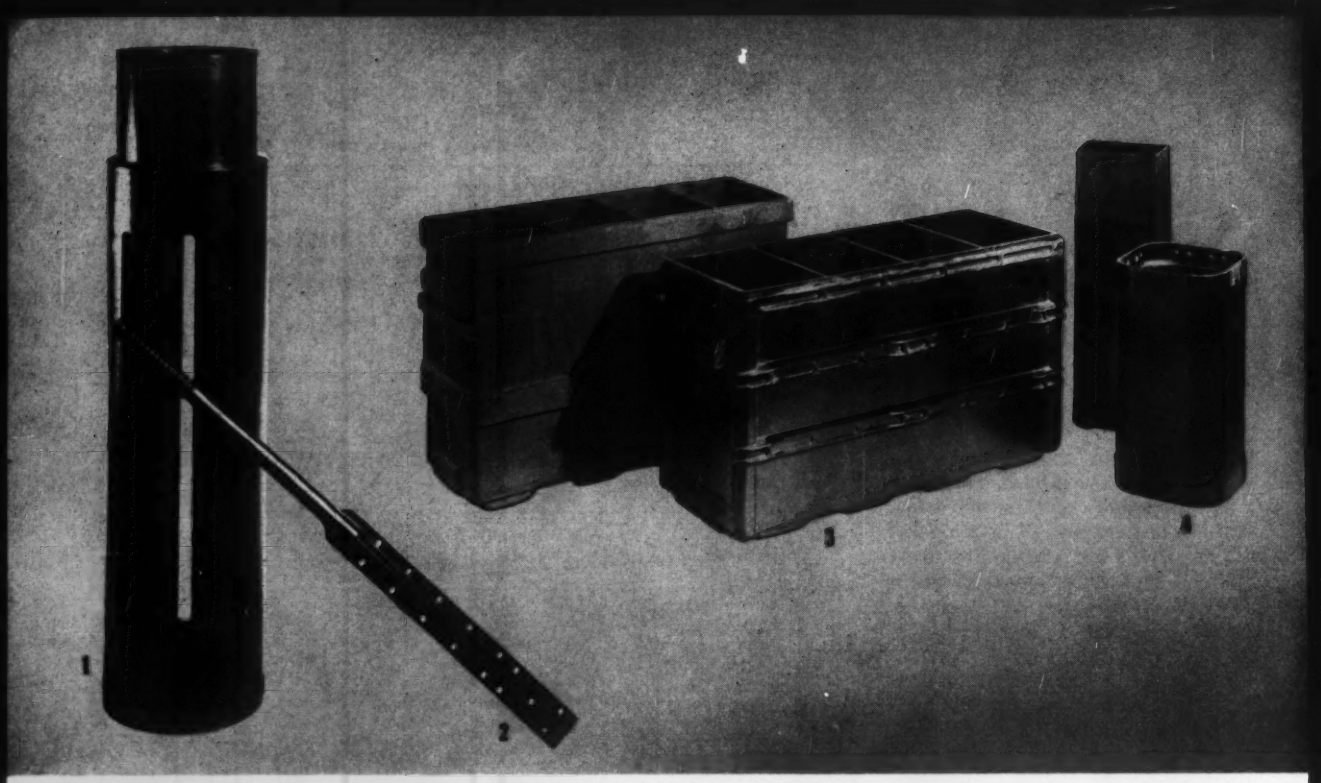
Drilling and reaming are conventional. Solid carbide or carbide-tipped drills with 90-deg included point angles are suggested for major drilling operations. Reaming is similar to drilling; the stock left for reaming after drilling varies with the finish required, depth of hole and chip capacity.

Beryllium Compared

How beryllium compares with other light metals for use in aircraft structures was the subject of a previous article in this magazine, Feb '57, p 100.

Electrical discharge machining has been successfully applied to beryllium by Northrop. Since the part is machined under oil, protection from dust is provided without special equipment. Greater dimensional accuracy and edge definition is achieved by this process than by any other machining process. No detrimental effects on the structure or impact properties result from the discharge, and there is no warping in the finished part.

Beryllium is particularly sensitive to grinding operations. A special abrasive wheel (designated "57A46-G12 VBED No. 24 treated" by Norton Co.) is required to minimize cracking that occurs with most abrasive wheels. Sensitivity apparently varies with the method of fabrication, decreasing in the following order: 1) extruded and rolled, 2) extruded, and 3) cast.



1, Tube for salt water valve. 2, Stirrer for photo solutions. 3, Railroad containers. 4, Industrial

Try Hard Rubber for Low Cost Parts

One of the earliest thermosetting molding materials, hard rubber still offers a high degree of versatility at low cost. Here are the properties and design recommendations you should know.

by Thomas E. Wallis, *Stokes Molded Products, Div. of Electric Storage Battery Co.*

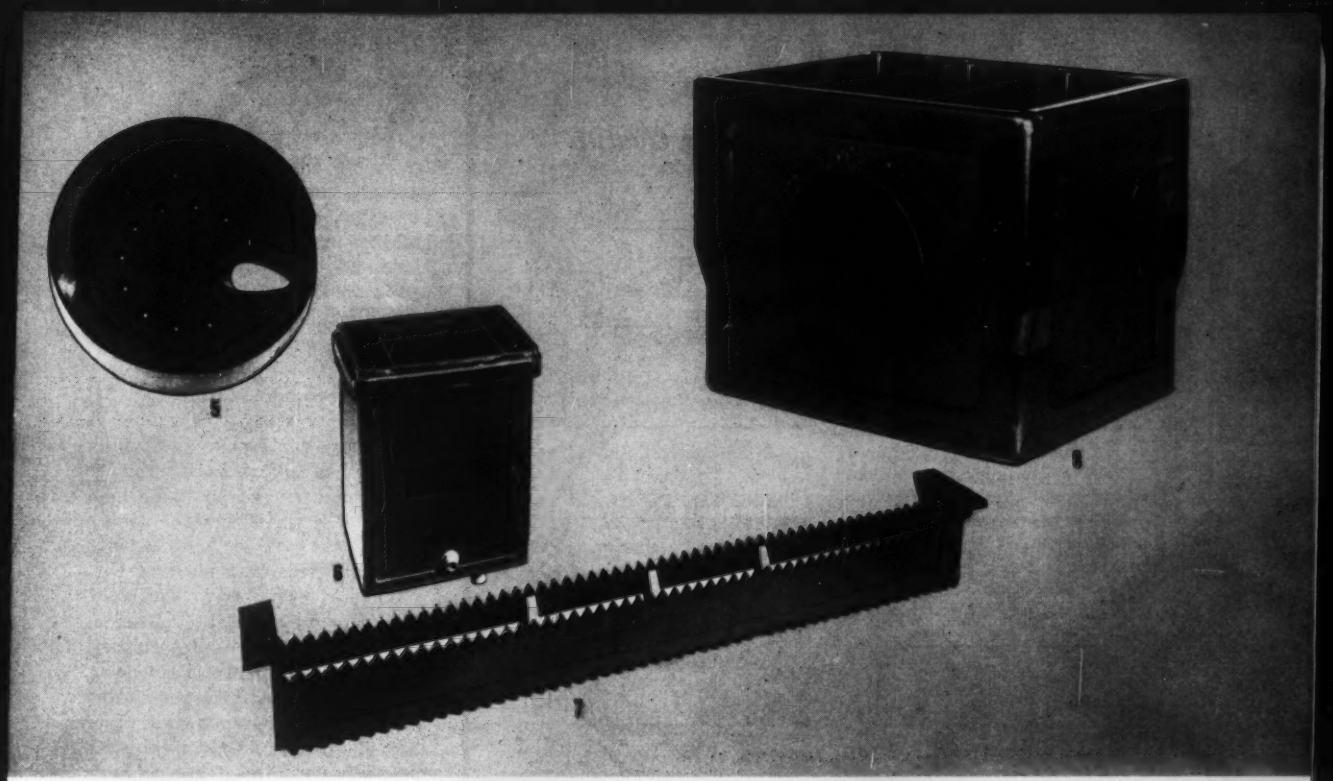
■ The most compelling reason for designing with hard rubber is low cost. The molding compounds are inexpensive, and fabrication or molding costs are usually lower than those for other comparable plastics. Yet engineering properties are relatively good, and can be varied extensively by altering either the compound itself or curing times and temperatures. Of plastics materials, polyvinyl chloride (PVC) has properties most similar to those of hard rubber. Thus, most comparisons in this article are with PVC.

The major limitation of hard rubber is colorability. Because of high sulfur contents colors are restricted to dark hues. Blues and reds are most common.

Cost considerations

Cost of hard rubber parts varies over a wide range. Typical prices of the three general grades of molding compounds are compared with those of PVC in the accompanying table. These prices may vary extensively depending on the costs of ingredients in specific formulations, as well as cost of fabrication. Ingredients in a compound may include any or all of the following: fillers such as lime, clay, carbon black, woodflour, metallic powders, or cotton or other fibers; softening agents; waxes; natural or synthetic resins; antioxidants; and organic accelerators.

In considering cost vs design requirements, remember that no single rubber compound can provide the best of all properties as well as the lowest cost. The optimum compromise must be reached for each design. Hard rubber compounds are not standardized, and compounds are tailor-made for specific applications. Thus the hard rubber producer should be consulted in the initial design



jars. 5, Water meter part. 6, X-ray tank. 7, Rayon trough. 8, Battery case.

stage to advise and quote on the most economical compound to meet design requirements. Cost variations between producers do not necessarily reflect on the efficiency of the producer, but more probably the quality of the compound he proposes to furnish.

Properties

Property ranges given in the table are typical for the Low, Medium and High Grades of hard rubber compounds. Though these properties can be altered substantially to meet specific needs, formulations differ so radically from producer to producer that further generalization would be meaningless.

For many uses the most important properties peculiar to hard rubber are the combination of relatively high tensile strength, low elongation and extremely low water absorption. Values for these properties can be improved somewhat over those shown in the table by specialized compounding, or by altering processing conditions.

The hardness, ranging from 55 to 95 points, is on the Shore D scale, which should not be confused with the Shore A scale used for soft rubbers.

In general, hard rubbers have good thermal and electrical insulating characteristics. They usually have greater dimensional stability than most other plastics, since cold flow is negligible. Resistance to aging is excellent.

Resistance to acids, alkalis and other chemicals is generally good; specific compounds should be tested for long-time stressed service in any given chemical environment. Hard rubber compounds containing butyl or nitrile rubber can be supplied where particularly good oil resistance is required.

Resistance to heat can be substantially improved over the val-

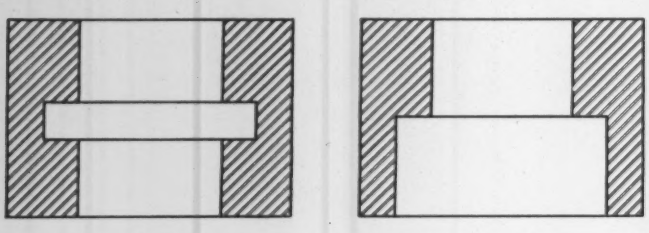
TYPICAL PROPERTIES OF HARD RUBBER[a]

Type →		Hard Rubber			Rigid Type I PVC
		High Grade	Medium Grade	Low Grade	
	ASTM				
Tensile Strength, 1000 psi	D530	5-10	2.5-5	0.9-2.5	8.5-9
Elongation, %	D530	4-50	4-50	2-20	15-30
Durometer Hardness (Shore D)	D676	55-95	50-85	50-85	85
Maximum Fiber Stress, 1000 psi	D530	44	15.2	1.75	15
Impact Strength (ball drop), in-lb	D639	10-100	10-100	10-100	100
Specific Gravity	D297	1.13	1.20	1.34	1.40
Heat Distortion Temp (264 psi), F	D648	155	110	115	150
Max Continuous Svc Temp, F[b]		190-300	135	140	165
Water Absorption (wt gain), %	D570	0.010	0.020	0.030	0.611
Acid Absorption (wt gain), %	D639	0.050	0.100	0.20	—
Dielectric Strength, v/mil		420-450	360-380	320	450-1300
Cost, $/lb		0.32	0.16	0.10 or less	0.37-0.45[c]

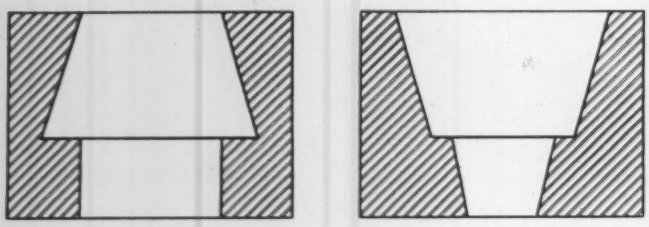
[a]Properties of rigid Type I PVC are given for comparison.
[b]This is the temperature at which the material can usually be used continuously in an unstressed condition.
[c]Typical price of molding compounds; unformulated resin price is about 28¢ per lb.

Do's and Don'ts of Hard Rubber Design

UNDERCUTS



Poor Good

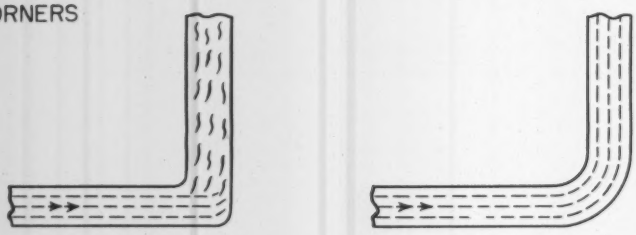


Poor Good

SECTION THICKNESS CHANGE

Poor Good

CORNERS



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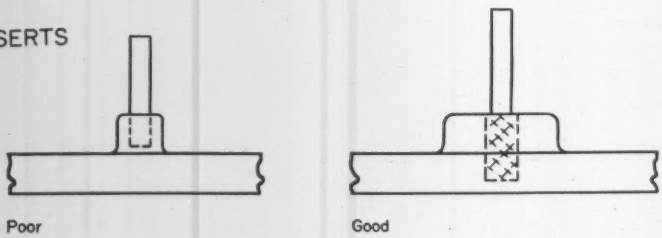
INSERTS



Poor Good

ues shown in the table by specialized compounding and curing. For example, one compound is available that maintains dimensional stability under non-stressed continuous service at temperatures up to 325 F. It also has good impact strength and chemical stability and retains the characteristic low water absorption.

Design recommendations

Designing with hard rubber is somewhat similar to designing with other plastics. There are differences which should be kept in mind, and in general design factors are not as critical with hard rubber as with plastics.

When removed from the mold, and prior to complete vulcanization, hard rubber is fragile and can be torn or broken. However, it is highly flexible, permitting molding of undercuts and other irregularities not practical with most other plastics. Hard rubber's high shrinkage can be used advantageously in some cases (see section on tolerances below), but it can cause excessive internal stresses in the molded part if proper precautions are not taken.

Following are eight general recommendations—some of which are illustrated in the accompanying sketches—for designing hard rubber molded parts:

1. Draft of 2 to 3 deg should usually be allowed on vertical sections. If undercuts are used, draft on the side of the part opposite the undercut should be large enough to permit removal of the part from the mold.

2. Undercut grooves should usually be machined rather than molded. Deep undercuts on the exterior of a part can be molded by split bars which are removed before the piece is extracted. This technique slows the cycle and increases cost.

3. Thickness variation should be kept to a minimum. This is particularly important in molding hard rubber, and especially where maximum tensile and impact strengths are required.

Cure time of a molding is based on time required to cure the thickest section. Since properties

Hard Rubber: An Old Material of Many Forms

What is hard rubber?

Hard rubber is an old engineering material. Essentially it is a highly vulcanized rubber with a maximum amount of sulfur (8 to 35%). The original hard rubber, ebonite, was made from natural rubber. It was hard, horny, and jet black in appearance. The bulk of today's hard rubber is made with SBR (formerly GR-S) synthetic rubber. Other types of synthetic rubbers, such as butyl or nitrile, or in rare cases silicone or acrylate, can also be used. Synthetic rubbers, as compared with natural, provide faster cures and improved oil, chemical and heat resistance.

The term "hard rubber" is self-descriptive. The hardness of hard rubber is measured on the Shore D scale, which is several orders of magnitude higher than the Shore A scale used for conventional rubbers and elastomers.

Classed as a thermosetting plastic, hard rubber is formed by heat and pressure. Subsequent heating completes the vulcanization or cure. Further heating would produce further curing until the degradation point was reached, after which the material would soften and physical properties fall off rapidly.

What forms are available?

Hard rubber parts can be compression or transfer molded, hand-wrap molded, or extruded in sheet, shapes, rod, pipe and tubing. After forming, parts are vulcanized in an autoclave.

Of the various molding methods transfer molding gives the most accurate dimensions and precludes excessive flash. Cure cycles can be reduced by proper selection of sprue sizes. Inserts can be incorporated readily. Transfer molding is preferred for small parts; usually a multi-cavity mold is used to obtain maximum production at lowest cost.

Compression molding is usually used for larger parts, though multi-cavity molds can also be used for smaller parts.

Hand-wrapping consists of wrapping cores or mandrels with partially vulcanized sheet and curing in an autoclave. Actually, it is a type of preform molding. The advantage of hand-wrapping is lower tooling cost. Disadvantages include high labor costs, low production rate, rough surface finish, and difficulty in holding dimensional accuracy.

Hard rubber sheet can be permanently bonded to common metals to form coatings. Such coatings can be used for corrosion protection, or for thermal or electrical insulation.

of a part depend on the degree of cure, large variations in thickness may mean that thicker sections cure to specifications while thinner sections over-cure. Over-curing produces a hard, brittle molding; under-curing produces a soft molding with excessive elongation and bulge. Different degrees of cure also result in internal stresses that can produce warpage or cracking in service.

Allowable variations of thickness in any given part depend on the compound used and the design requirements of the part. When large flat surfaces are produced in hard rubber, thicker sections or bands around the periphery should be avoided.

4. Corners should have ample radii. The radius on any inside or outside edge or corner should be at least 1/32 in. Sharp corners, of course, weaken the part. Rounded corners also aid flow during molding; material may lodge in a square corner and impede even flow, resulting in flow marks and nonuniformity.

5. Brass or brass-plated inserts should be used for a particularly good bond. Compounds have been developed which improve bonds of hard rubber to steel, lead and other metals. When inserts other than brass are used, they should usually be knurled to provide a better mechanical bond.

Inserts hold their position well in hard rubber because of the material's softness in the molding condition and the fact that it can be closely preformed to the final shape of the piece. Even floating inserts can be molded relatively easily.

Ample material should be provided around any insert. Bosses should be three times the diameter of the insert; inserts in bosses should extend into the molded part for added strength.

6. Threaded, molded holes should have a length-to-diameter ratio of 3:1 or less. Threads in holes should not start closer than 1/32 in. from the surface. Male threads also should not start closer than 1/32 in. from the end. Feather edges on either type of thread should be avoided.

7. Tolerances closer than actually needed should not be specified. Tolerances are generally not as critical a tooling consideration with hard rubber as with most plastics. Dimensions of finished parts can be altered by post-heating to shrink the part, or drying to expand the part. Whether this can be done or not, and the degree to which it can be done, depends primarily on the shape of the part and the compound. For example, a 4-in. dia hard rubber ring was initially molded to specified tolerances. Later it was found that the ring would not fit the equipment for which it was designed. A shrinkage of 0.0015 in. on the 4-in. dia was produced by post-heating, and the rest of the production order was produced in the original molds and shrunk to fit after molding.

8. Surfaces of large, flat areas where appearance is important should be pebbled or otherwise broken up. If left smooth such areas are likely to show shrinkage marks, particularly when high grade rubber stocks are used.

These high strength parts were made without heat treatment from . . .

Stronger Carbon Steel Bars

produced by elevated temperature drawing

***Transmission main shaft** requires extensive machining, including a 6-in. length to ±0.005-in. accuracy with a surface finish of 15 µin. rms. Formerly produced from A4140 steel, now produced from elevated temperature drawn (e.t.d.) C1144, eliminating heat treatment and improving machinability.*

***Piston rod** for double-action punch press and riveting machine was originally produced from alloy steel heat treated to Rockwell C28-33. Converting to e.t.d. C1144 eliminated heat treatment and distortion; improved wear resistance.*

by E. S. Nachtman,
Director of Research and Development, La Salle Steel Co.

■ Elevated temperature drawing of steel results in finished bar stock having a unique combination of strength, dimensional tolerances, surface finish, formability and machinability.

Parts having uniform properties and excellent fatigue resistance can now be produced without heat treatment; thus costs associated with heat treating, cleaning and straightening can be reduced or often eliminated. At present, only free-machining C1144 is available commercially in this new condition but other steels, including alloy grades, are under development.

What is elevated temperature drawing?

Elevated temperature drawing (e.t.d.) is a modification of cold drawing in which the bar is worked in the 200 to 1200 F range. By the classic definition, i.e., working below the recrystallization temperature, this operation is still considered cold drawing, but increasing the temperature above ambient has a marked effect on strength.

For example, it is possible to choose a temperature for drawing to obtain exceptional ductility in the finished bar with nominal strength. Alternately, the temperature can be selected to obtain high tensile and yield strengths. In addition, exceptional proportional limits and excellent stress-strain characteristics result from e.t.d.

The new development produces a stronger product than is obtained by stress relieving after cold working, and also eliminates the stress relieving heat treatment. The relative effects of e.t.d. and the conventional procedure are shown in Fig 1 for C1144 bars. Tensile strength of stress relieved cold drawn bars is only slightly higher than that of the unrelieved bars, whereas e.t.d. increases strength markedly. The yield strengths show similar effects, although the differences are less pronounced.

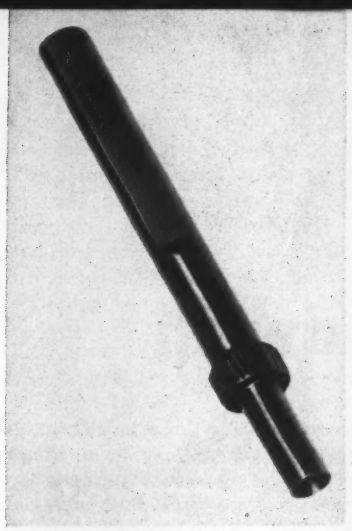
Properties

Properties obtainable by elevated temperature drawing of several standard steels are shown in Fig 2. Three of these steels are carbon grades. The fourth, a chromium-molybdenum grade, is included to show that property improvement is not confined to carbon grades. Because the degree of deformation influences the properties, the graphs show mechanical properties after two different reductions.

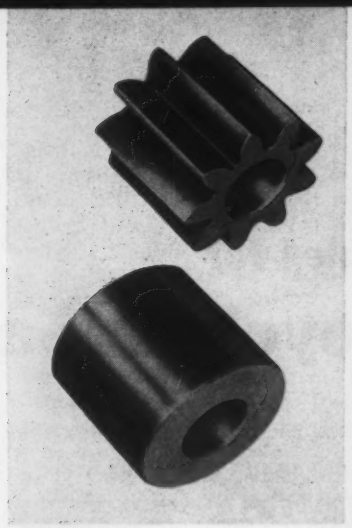
Tensile and yield strengths increase to a maximum in the 500 to 600 F temperature range; elongation and reduction of area reach a minimum in the same temperature range. Increasing the amount of reduction increases the strength at any temperature, but not proportionally.

The percentage increase in strength resulting from e.t.d. is apparently independent of the carbon content. Elongation and reduction of area decrease with increasing carbon content.

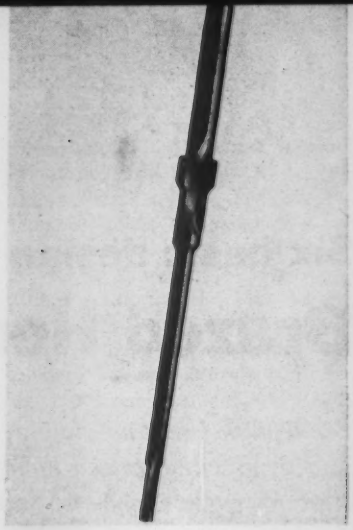
The decrease in impact strength that results from cold drawing occurs also in e.t.d. However, maximum strength and minimum impact properties do not occur at the same temperature. In the commercial carbon steels, the dip in



Electric motor shaft *has a knurled section over which a bronze gear is forced; the knurled section securely holds the gear. When the shaft was made of heat treated 4140 steel, the knurls bent instead of biting into the gear. Conversion to e.t.d. C1144 overcame the difficulty.*



Oil pump gear *was formerly blanked from cold drawn C1144 and hardened to Rockwell C29-35. Necessity of holding minimum hardness 3/8 in. below surface caused machining problems. Trouble was overcome by changing to e.t.d. C1144, which could be used without heat treatment.*



Step-down reamer *used for machining textile bobbins was converted to e.t.d. C1144 from heat treated, strain relieved Hy-Ten steel. Reamers produced from C1144 could be used to produce 20,000 bobbins without significant effect on the cutting edge; Hy-Ten reamers were changed after producing 5000 units.*

the impact curve occurs in a narrow temperature range, whereas the choice of a drawing temperature to achieve desired tensile properties is quite broad. Therefore, it is possible to choose a temperature for drawing at which a combination of high strength and good impact values is secured.

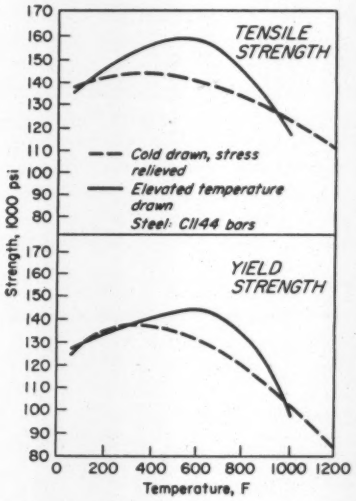
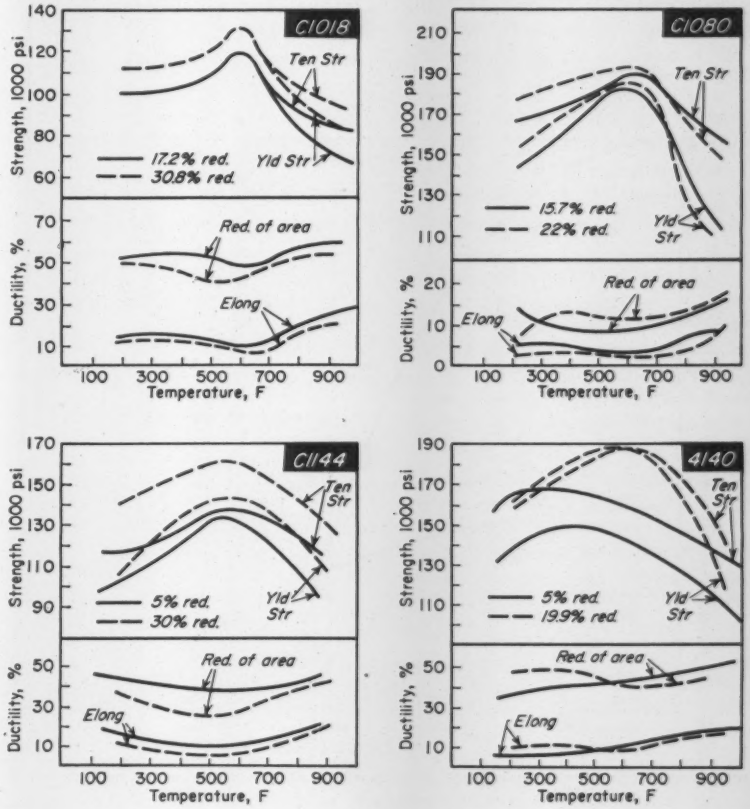


Fig 1*—Higher yield and tensile strengths are obtained by elevated temperature drawing than by cold drawing followed by stress relieving.*

Fig 2—Properties of four steels after elevated temperature drawing.



Six basic design rules for
Brazed Honeycomb Sandwich

Six design fundamentals are keys to practical, economical and producible brazed honeycomb sandwich. The first four are concerned with the effect of brazing on design. The last two can increase the efficiency of the sandwich in the end product.

by Floyd F. Rechlin, *Project Engineer, Solar Aircraft Co.*

1. Select materials to withstand brazing conditions

Normal structural design is concerned with withstanding flight or applied loads during stipulated lengths of exposure at service temperatures. When designing brazed honeycomb sandwich structures, another set of design temperatures and pressures must be considered—those encountered in brazing. They affect internal structural composition as well as external configuration.

Pressures needed to maintain intimate contact of components for brazing are much lower than service pressures. Brazing *temperatures*, however, may be as high as 2200 F for as long as an hour. Thus the metal will be near the plastic state and the effect of brazing pressures must be taken into consideration when selecting materials for the core.

The graph (Fig 1) shows the compressive strength of honeycomb core made from 17-7PH/TH1050 and Inconel. In most designs, the designer is concerned only with the unshaded area of the graph. For a honeycomb sandwich component, however, the designer must also consider the strengths shown in the shaded area of the chart. A core size and density adequate to withstand flight loads at service temperatures might be incapable of meeting the pressure requirements at brazing temperatures.

Not too much is known of the strength properties of honeycomb core at high temperatures, as indicated by the "extrapolated" notation on the graph. Nor is much information available on the brazing pressures to consider when specifying core density. The problem is complicated by the fact that each design requires a pressure range of its own. Greater pressures than those needed to hold the facings flat to the core blanket

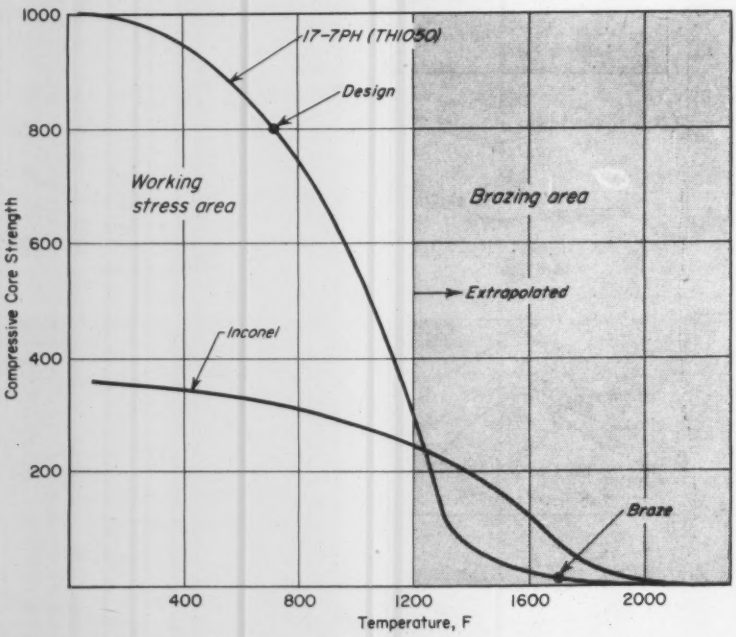


***Fig 1**—Brazing area in extrapolated portion of graph indicates need to consider brazing temperatures and pressures in design of honeycomb sandwich.*

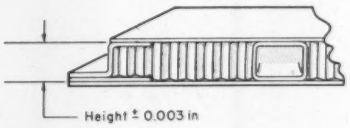


***Fig 2**—Height tolerances of ±0.003 in. must be held in order to maintain intimate contact between surface to be brazed.*

are required when heavy gage faces, incorporated doublers and/or edge members, must be brazed together. Because pressure is distributed uniformly, these higher pressures must also be withstood by the core.

The only recourse a designer has is to consult his materials and processes groups, or a proven brazing facility, to determine whether the core density selected is adequate to meet the brazing pressure and temperature requirements. One general rule that might be applied: Avoid extremely thin foils, 0.001 in. and below, unless the facings and edge members are relatively thin.

The influence of the brazing alloy on the selection of core density is not great in the present era of silver-base alloys. If high temperature materials and brazing alloys are being considered, however, the metallurgical effect of the braze alloy on the core foil during brazing operations should be investigated.

2. Design around narrow tolerances

A basic requirement when brazing honeycomb sandwich is to maintain intimate contact between all members being bonded together. To achieve this intimate contact, height tolerances on the order of ±0.003 in. must be held on all integral parts of the assembly.

The ability to hold such tolerances, especially in the case of formed sheet metal parts, greatly influences producibility and cost. Consider the typical cross section shown in Fig 2. In this design the heights of the edge members, spar and core blanket are all subject to the same ±0.003-in. tolerance. In addition, the core above the doubler must have a step machined in it to within ±0.003 in. of the doubler thickness. The tolerance problem would be amplified if the sandwich panel were curved.

The influence of these tolerances can be relieved by attention to detail design. Because the core blanket can easily be surfaced to accurate dimensions, a practical design approach is to concentrate height tolerances on the core and try to eliminate formed members with fixed heights.

To illustrate this point, note the conventional channel member shown at *A* in Fig 3. By accepting a small weight penalty, the channel could be redesigned as two adjustable angles as shown at *B*. After these angles were positioned to match the core height, they could be tack welded to the core and the whole unit brazed to form a solid component. A still further improvement on edge member design would be to eliminate the vertical legs altogether and substitute dense core to transmit panel loading, as illustrated at *C*.

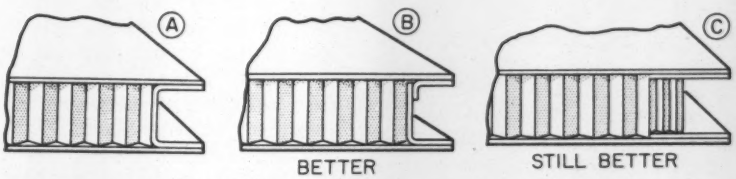


***Fig 3**—Conventional channel member* (A) *can be redesigned* (B) *to minimize detail subject to close tolerance. A better solution may be the use of dense core* (C).

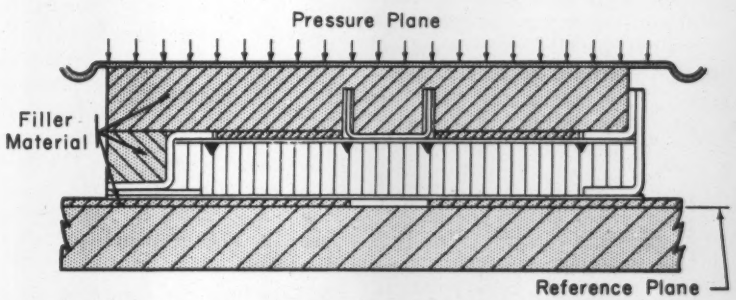


***Fig 4**—Design with extensive projections requires large mass of filler material to obtain uniform planes for brazing. Such filler material forms a large heat sink. This sink, plus differences in thermal expansion, may result in no effective brazing at points marked with triangles.*

3. Provide uniform pressure and temperature distribution

Another requirement of the brazing process which influences design is the need for uniform pressure planes and heat distribution. The ideal brazing configuration would be a flat sandwich without external steps. Even minor deviations from this configuration must be compensated by filler sheets or filler material to provide even pressure planes on both sides. A small amount of filler material can be tolerated, but if the configuration extends too far from the normal plane of the sandwich the mass of filler material tends to become a heat sink. Uneven temperature distribution increases the possibility of producing only a partially brazed part.

The hypothetical design of Fig 4 (unshaded area) not only has extended edge members but also has an external channel along the center of the panel and a doubler located on the opposite face. Addition of the required filler material not only results in unequal heat distribution but also fails to guarantee perfectly distributed pressures. The filler material must be shaped to compensate for the difference in thermal expansion between itself and the sandwich material at brazing temperatures. Areas could occur, as shown by the dark triangles, where no brazing pressures would be exerted.

It is true that external stiffening members or attachment fittings cannot be avoided in most structural applications. But close

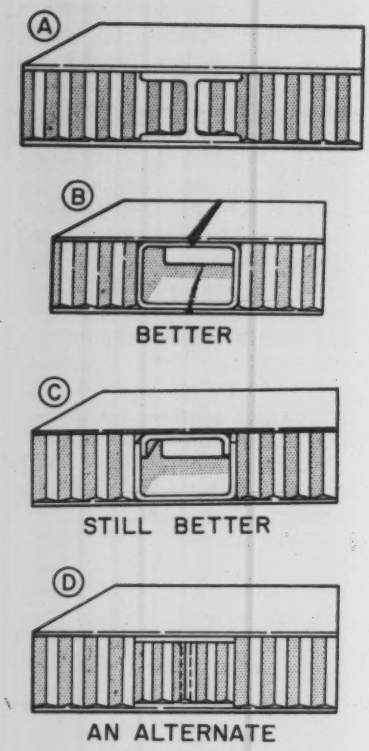
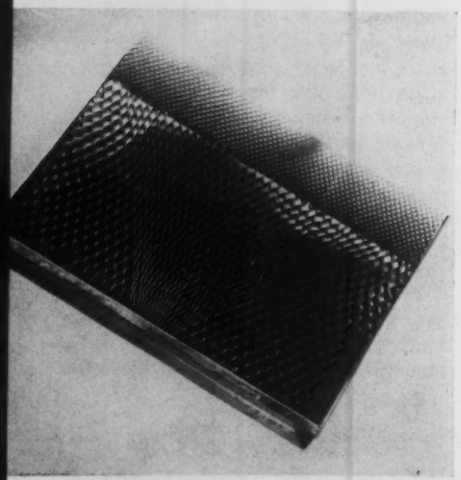


Fig 5—*Integral shear ties must exist for proper brazing to occur. Design* A *fails to make provision for this. In* B *each channel can first be tack welded to the core.* C *has the additional feature of avoiding tolerance problems.* D *replaces the spar with dense core and is usually the best design.*

Fig 6—*Varying core density provides wide design opportunities, as shown in this core blanket for a small missile flipper.*



attention can be paid to the detail design of these components to minimize projections away from the face of the sandwich. A more producible sandwich structure is often realized by attaching these members, wholly or in part, after brazing.

4. Plan for effective brazing assembly

As part of the layup procedure, provisions must be made to guarantee shear ties and structural strength by tack-welding the core to the vertical faces of included members. Vacuum pressure accomplishes the necessary ties in one direction—normal to the face planes. Fastening or welding methods must be employed between surfaces not affected by this pressure.

The designs of Fig 5 are solutions to the problem of providing a structural spar through the center of a honeycomb sandwich. Conventional airframe design practice has established the I-beam section *A* as normal choice for this spar. Yet no way exists to establish a shear tie between the core and the web of the I-beam.

A better spar configuration for honeycomb sandwich construction is the box section *B*. This is formed by fusion-welding two channels together after the core has been spot-tacked to the individual channels. The design shown at *C* may be still better because of the greater case of producibility. However, provision must be made to insert a backup electrode to accomplish the necessary tack-welding of the two pieces. Box beams of either type do introduce a weight penalty over standard I-beam extruded or forged material.

One other method is shown at *D*. This design substitutes dense core for the I-beam web, but it should weigh the same. The spar caps are simple doublers, with height tolerances entirely concentrated in the core between them.

5. Vary core density to transmit loads efficiently

The use of varying density core presents unlimited design opportunities. A certain amount of splicing is necessary anyway to achieve the final size and shape needed for a sandwich core blanket; it costs little more to incorporate different densities. Not only can densities be varied by inserting areas of smaller cell or heavier gage core, but sections of the normal core blanket can be readily shaped or crushed during the layup stage to form load carrying paths. Once the core has been spliced in place, it is machined and brazed as a unit, resulting in a permanent internal structure.

Fig 6 shows a typical example of the use of such varying core densities in the edge members and core blanket for a small missile flipper. Compressed core is employed in a fan-shaped pattern to concentrate loads at a central section. The trailing edge is made up of smaller cell core to permit feathering the core at the sharp trailing edge while still insuring maximum skin stabilization.

Use of smaller cell core is also recommended along the trailing edges of missile wings with blunt edges. The slight pitch of the exposed core walls usually provides a smooth enough surface. For further aerodynamic smoothness, a strip of foil material can be brazed along the edge, or the indentations between cells smoothed out with filler.

When fasteners are required in the sandwich, insertion of a small area of denser core in the parent core blanket offers greater local compressive and bearing strength. Fig 7 shows a typical fastener inserted through densified core in a honeycomb sandwich structure. In this particular instance, doublers were also included on either side of the core blanket to aid in load transmittal. The fastener can either be brazed or mechanically locked in position, depending on the degree of shear that must be transmitted.

6. Consider the sandwich as a material

Honeycomb sandwich technology is reaching the point where the sandwich can be regarded as a

material rather than a build-up structure. It is expected that it will soon be possible to take flat honeycomb sandwich panels "off the shelf," not only to rough-cut them to size or to finish-machine them, but also to attach required edge members, to join small panels together, and even to form panels to desired shape or curvature.

Attaching members — Attachment of edge members to simple panels can be accomplished in a number of ways. Mechanical means, using doublers and dense core, is an established method. Solar Aircraft Co. is investigating secondary brazing.

In the case of very large panels, brazing has been done with a C-shaped furnace which travels along the edges. Fig 8 shows a typical secondary-brazed edge member (here the doubler itself was also secondarily brazed in place). A recent program determined that doublers could be successfully located as far as 0.050 in. from 0.010-in. faces without reducing load transfer strength. This spacing eliminates the risk of cutting into the parent metal of the facing when machining a slot for secondary insertion of the doubler.

Joining panels — Applications often arise which require extremely large sandwich panels. Two choices are available; to find or build a facility large enough to accommodate the larger area, or to connect a number of smaller panels at a slight weight increase.

Fig 9 is a cross-sectional photograph of one design approach toward joining panels, in this case by welding. Due to inaccessibility, no shear tie exists between the two core sections. Such a tie could be provided by machining the skins back far enough to expose the core for welding access. To eliminate the expense of such an operation and still make up for the lack of shear tie, the core along the edges of each panel was densified to aid in transmitting loads into the doublers. The doublers are needed to lessen the annealing effect of the welding operation.

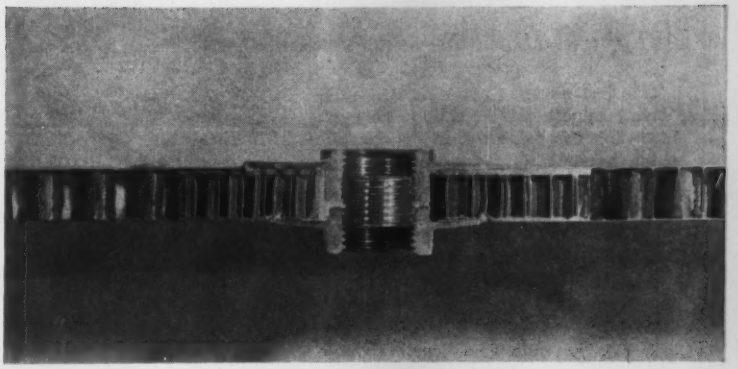


Fig 7—*Densified core provides adequate strength for integral fasteners.*

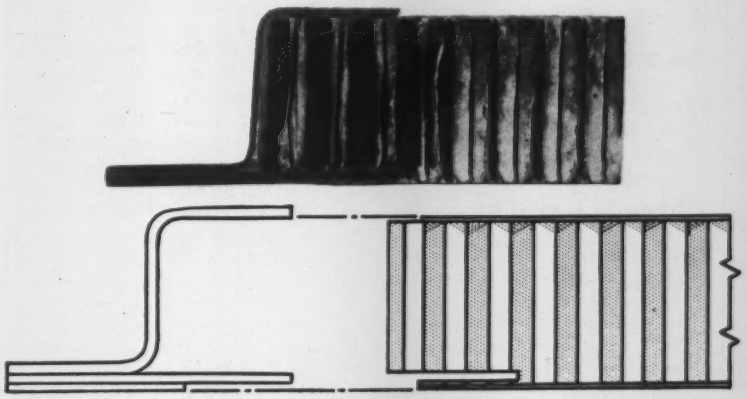


Fig 8—*Secondary attachment of edge members to simple panels is an example of treating sandwich as basic material.*

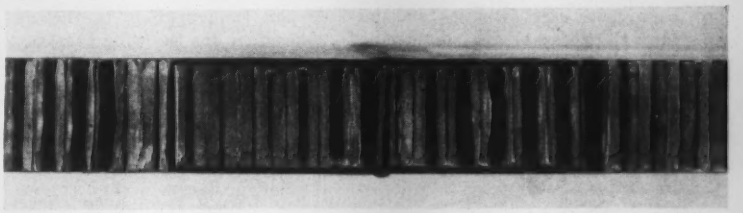


Fig 9—*Large sandwich panels may be made up by connecting a number of smaller panels, using doublers and dense core.*

Such joining techniques are entirely feasible for honeycomb sandwich structures, although care must be taken to minimize distortions or thermal stresses which might be built up due to improper welding call-outs or weld locations. Tests on this type of construction have shown that proper welding does not disrupt the braze alloy underneath the weld, nor does the brazing alloy, in this case sterling silver, have a detrimental effect on the physical properties of the weld.

Forming panels—Solar Aircraft Co., in cooperation with the Hufford Corp., has engaged in a stretch forming program on honeycomb sandwich. Initial study has concentrated on determining the minimum bend radius to which honeycomb sandwich panels can be formed without reduction in physical properties. To date 24-in.-

A Typical Problem—and Its Solution

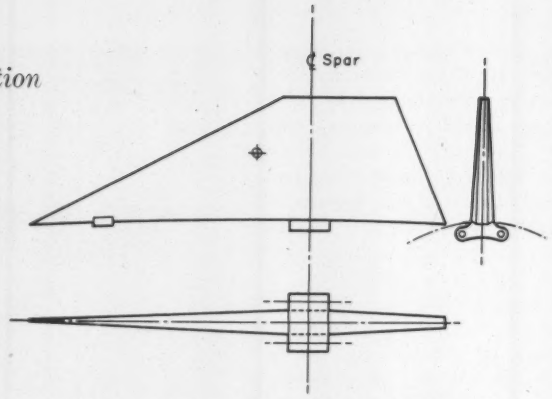
The first sketch at the right depicts a hypothetical envelope configuration for a large missile wing which must satisfy the following design criteria:

1. High strength-to-weight ratio with minimum flutter under load.
2. Surface able to withstand maneuver loadings and service temperatures of 1600 F for a few minutes.
3. Aerodynamic smoothness discontinuities permissible at wing-to-body intersection; only leading edge need be sharp.
4. Central spar and close-out edge member adjacent to missile body shell to transmit major loads.
5. Shear fitting located near forward edge.
6. Attachment fitting in wing surface for launching or ground handling equipment.

Steps to a solution

Following is the theoretical line of reasoning that might be employed to arrive at a practical and producible design:

Select material—Honeycomb sandwich construction is indicated, not only for the light weight, but for high rigidity and multi-directional load carrying. The basic material selected is a high temperature material such as Haynes 25. Basic honeycomb core densities and facing thicknesses are determined from the strength properties of the material selected.



Problem: *Design this hypothetical envelope for a large missile wing.*

Select brazing alloy—The next step is to select the brazing alloy needed to meet the temperature requirements. Consideration must be given to the ability of the designated core density to withstand the anticipated brazing pressures and temperatures and to be metallurgically compatible with the selected brazing alloy.

Members for secondary attachment—In starting the detail design, the first step is a study of deviations from the normal flat sandwich plane. The spar fitting falls in that category. The large mass of this fitting will also form a heat sink. It would be best to attach this fitting after core brazing.

Design keystone — The integral spar configuration is the design keystone for the wing construction. Of the designs in Fig 5, *C* is chosen if the thin outboard edge permits enough access to complete welding operations. If not, *D* is the choice. Provision must also be made for final attachment of the spar fitting.

One possible solution is shown in the small sketch. The spar caps or doublers are formed at the inboard ends to provide a receptacle for later insertion of the forged fitting. The core blanket can be easily attached to the back face of the fitting pocket before brazing, insuring shear transmission through the fitting. Note that the core blanket under the spar caps is made slightly oversize to permit the machining of accurate steps to accommodate the spar cap material.

Design details — The structural configuration of the wing edge member, main core blanket and facings is considered next. Many combinations could be applied to this particular wing. The idea of

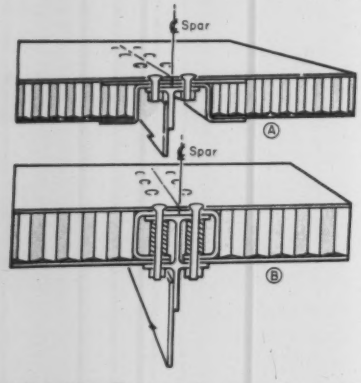


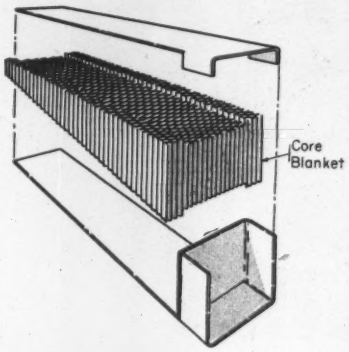
Fig 10*—Typical honeycomb panel wing-to-spar intersection brings up problems of load transference.* A *introduces weight penalty,* B *both weight and accessibility problems.*

radius panels have been successfully stretched with no discernible core crushing. There still are many problems to be solved, such as degree of springback and elimination of bowing, but the process shows promise for future designs.

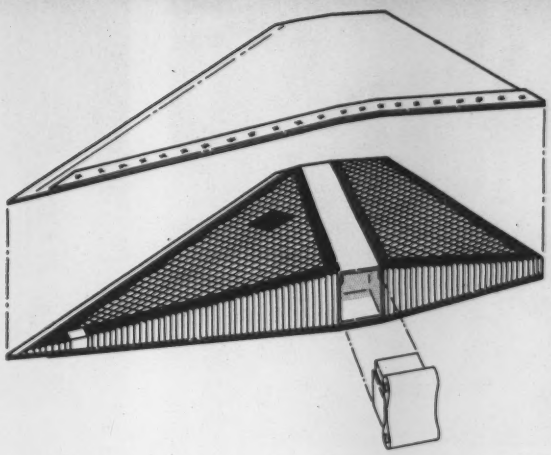
Transferring loads—Once it has been brazed, honeycomb sandwich becomes a structural material of finite thickness. Adequately transferring loads from both faces through mechanical joints, while still accommodating this established thickness, can prove a challenge.

As an example, consider a typical honeycomb panel wing-to-spar intersection (Fig 10). In most cases, access to the inside of the wing for mechanical fastening is not possible because of the sealed closure requirements of the modern day wet wing. The design shown at *A* offers easy access for panel replacement but introduces an undesirable weight penalty. The Z-section and doubler combination must be sufficiently heavy to transfer loads from the inner skin of one panel, up over the spar cap and down to the inner skin of the adjacent panel.

The most efficient way to transfer loads would be directly through the spar cap with no directional



Design keystone *is central spar. Dense core is used and method is provided for attaching spar fitting.*



Solution: *Complete design uses core of varying density plus doublers and welded skins.*

using a wrapped skin, for instance, might be considered and then discarded due to the requirement for a sharp leading edge. Edge member design would probably end up being a choice between a formed sheet metal channel and a doubler-densified core combination. In order to eliminate the close brazing tolerances that a curved sheet metal channel would have to satisfy, the latter might well be the final choice.

Final design—The resulting wing design is shown in the final sketch. Note the following details:

1. The basic core blanket incorporates a thin band of smaller cell core at the leading edge. The dense band permits the core to be machined to a feather line while retaining maximum skin support.
2. The skins are welded together along the sharp leading edge.
3. The forward shear attachment is buried in the core blanket.
4. Loads are transmitted along the inboard face by the doubler-densified core combination. The doublers are resistance welded to the outside of the faces prior to brazing, avoiding the more costly process of machining a tapered step in the core to accommodate them internally.
5. The trailing edge of the wing consists of a strip of denser core to aid in surface rigidity. In addition, the slightly corrugated face of the smaller cell walls could be considered an acceptable substitute for an incorporated closure member.
6. At the ground handling attachment point in the wing, another small piece of densified core is spliced in place to accommodate the insertion of the required fitting.

Layup procedure—To check the manufacturing feasibility of his design, the designer mentally engages in a step-by-step layup procedure. The progressive steps: form the core blanket into a rough shape; splice in all densified core members; machine the blanket to the desired taper; cut the step in the core needed for the spar assembly; place the lower half of the spar cap in the core blanket; tack weld the fitting pocket to the faying nodes of the core blanket; lay the top portion of the spar cap in place and resistance weld it to the lower half; position the forward shear fitting and tack it to the core blanket; load the brazing alloy; lay the two face skins, along with the previously attached doublers, on either side of the core blanket and braze the whole unit together; slip the spar fitting into place and fasten it by secondary brazing or welding, or by mechanical means.

change, as shown at *B*. To allow the panels to be unfastened from the outside and still insure a mechanical tie, some kind of spacer would have to be employed. Locating these spacers could be a monumental task and their added weight, along with that of the extended length bolts, is not desirable. In addition, the interlocking effect produced between the extruded spar cap, the channel edge members and the spacers could make removal of panels a difficult operation.

One possible solution to this problem is shown in Fig 11. Here loads are transferred directly across a cap strip, which is welded in place on the outside of the sandwich after the panels have been bolted to the spar cap. To replace these panels, the cap strip could be ground off, and another strip welded in place upon completion of the bolting operation.

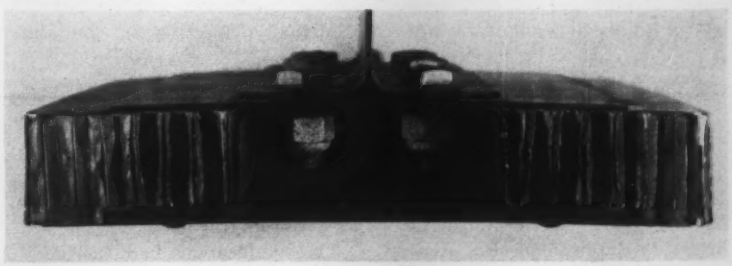
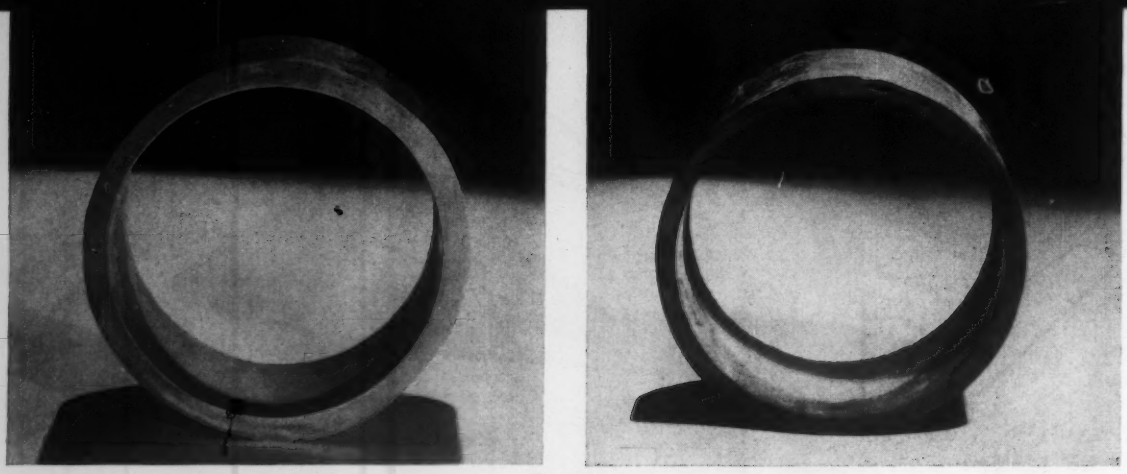


***Fig 11**—One solution to problem of Fig 10. Cap strip is welded to outside after panels have been bolted to spar cap.*



PIPE

Good *Resin and reinforcement blend smoothly into integral whole. Good concentricity and smooth interior surface.*

Poor *Voids in laminate reduce mechanical properties. Internal surface is somewhat rough, and pipe has poor concentricity.*

Visual Standards for Reinforced Plastics

Visual inspection can go far in telling you whether a reinforced plastics part is serviceable. Here are photographs that show what to look for in checking your part against materials specifications.

by W. E. Smith and W. A. Severance, *Ceilcote Co.*

Large reinforced plastics structures, such as ventilating hoods, and ducts and stacks for processing equipment, are usually fabricated by contact molding or hand lay-up techniques. Quality of such parts is highly dependent on individual workmanship. Thus, after specifications have been prepared, engineers and designers must have a means of evaluating the workmanship as it affects serviceability of the part.

Visual inspection is the simplest, easiest way of telling the quality of a part. The appearance of reinforced plastics parts produced by various fabricators may differ. Also, in some cases appearance may not be indicative of serviceability. However, there are certain easily detected defects that do affect serviceability. Visual identification of such defects can eliminate some of the more elaborate inspection procedures, and may avert a failure in service.

The following visual standards show several design configurations that occur often in large reinforced plastics shapes. In each case, a well fabricated part is compared with a part containing an important defect that is common in that type of configuration. A word of caution: The type of service for which a part is intended should always be carefully considered during evaluation of defects. A defect in a critical structure, such as a tank or process vessel, may not necessarily be considered an important defect in a less critical part, such as a fume duct.

. . . and suggested materials specifications

Here are probably the first published suggested specifications for fabricated reinforced plastics structures. They have been prepared to indicate the important materials requirements your fabricator must know in order to properly fabricate serviceable structures.

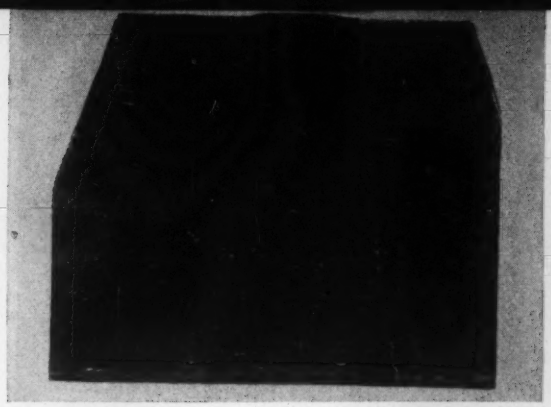
The specifications here include:

1. *General Specifications* — These are pertinent to all types of large reinforced plastics constructions.

2. *Standard Specifications for Ventilating Equipment*—This is an example of a specific specification for a particular type of equipment.

General specifications

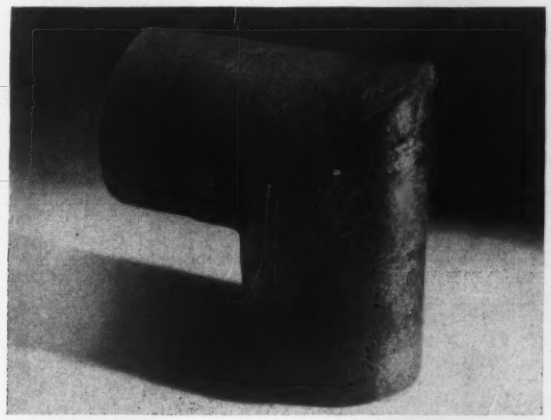
1. Construction details and overall

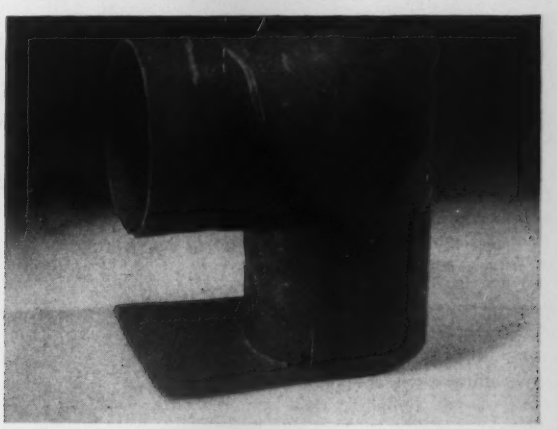


BUTT JOINT

Good *Two pieces butt perfectly without gaps or misalignment, providing best structural strength. High quality of strapping job is indicated by uniform appearance of strapping material, both at the end and across the surface of the joint. Edge view shows uniformity of thickness of two joined sheets.*

Poor *Misalignment of butted sheets causes step. Gap shown at joint reduces structural strength and provides void for introduction of corrosive materials. Run-off rivulets at upper right are caused by resin draining away from the white, "resin-poor" area, resulting in lowered mechanical properties and possible leakage.*

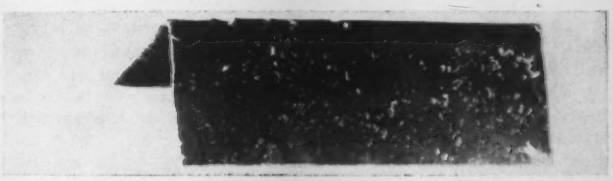




MITRED ELBOW

Good *Joint is close fitting; strapping is neat and shows excellent adherence. Interior wall is devoid of pits, permitting smooth flow of gases or liquids. Absence of "steps" in joint area indicates that parts are concentric.*

Poor *Heavy gray stripe along joint indicates improper fabrication which could cause serious loss of tensile strength. Interior has objectionable pitting and roughness.*



MOLDED CORNER

Good *Surface is devoid of pitting and pinholes. Lack of pits is good indicator of skillful fabrication and proper handling techniques. Pits can act as collection points for corrosive substances.*

Poor *Amount of pitting shown would be cause for rejection. Actual acceptable amount of pitting depends on anticipated service. Dry chemical fumes would probably not greatly affect heavily pitted laminate; wet concentrated fumes would reduce mechanical strength and eventually cause leakage. Regardless of end use, pits larger than ⅛ in. dia merit special attention.*

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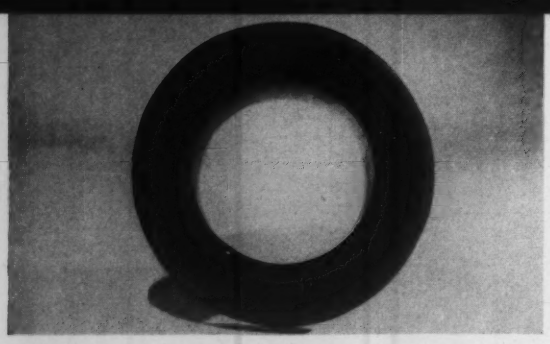
dimensions shall be in accordance with the purchase order and drawings submitted by the purchaser. Designs prepared by the vendor must be approved in advance by the purchaser. Design and construction details, and minor variations thereto, shall be reviewed and agreed upon between the vendor and purchaser. Copies of the approved drawing shall be supplied to both parties.

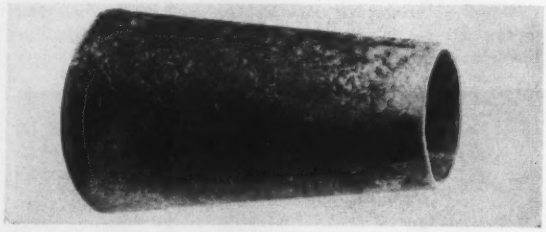
2. Correct fabricating techniques



FLANGE

Good *Face of flange is smooth and flat, providing good sealing qualities. Interior surface is smooth and concentric. Holes in duct flanges should be drilled in field for best alignment; holes in pipe flanges are generally shop-drilled.*

Poor *Large voids could cause leaks around gasketing material. Two additional defects not shown here are: 1) dishing (a form of warping), which would prevent tightening the flange sufficiently for a good seal, and 2) resin drainage from the strapping behind the flange face.*



REDUCER

Good *Even color and surface indicate good saturation of sharply sloping surface, and consistent resin distribution. Even distribution is particularly important in wet or humid corrosive service.*

Poor *White splotchy areas indicate resin drainage that has left laminate dry and pithy. Such areas have low tensile, flexural and impact strengths, and may permit leakage in wet corrosive service.*

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in keeping with the highest standards of the industry shall be employed. All laminates shall be of uniform thickness with uniform distribution of glass reinforcement. Laminates shall contain 18-20% glass mat and/or woven fibers. Reinforcing members shall be in accordance with good fabricating practice for reinforced plastics structures. Voids, dry spots and/or cracking shall constitute cause for rejection.

3. The manufacturer and purchaser will agree in advance of fabrication on the permissible size and extent of air bubbles, pits and other blemishes. There shall be no evidence of unsaturated fibers, resin richness, dryness, or resin run-off.

4. All edges shall be coated with resin to assure maximum chemical resistance. All joints shall be filled, where possible. Joints and connections shall have resin-glass reinforcement which is equal in strength to the strongest of the components being joined.

Specifications for ventilating equipment

1. Plastics ducts and hoods shall be fabricated of chemically resistant (polyester or epoxy) resin reinforced with glass fibers. The finished product to contain a minimum of 15% glass and a maximum of 0.5% pigment or dye.

2. Finished laminates shall be uniform in thickness and adequately joined using same material. Exterior surfaces shall be of uniform mat texture with no unsaturated reinforcing fibers. Finish coats may be applied but are not specified. All ventilating components shall be fabricated with a smooth interior surface.

3. Thickness schedules shall conform to following:

Sheet Stock

Sheet shall be specified in standard thicknesses of 3/32, 1/8, 3/16, 1/4 or 3/8.

Round Duct and Molded Structures

I.D. Size, in.	Thickness, in.
4-14	3/32
16-28	1/8
30-54	3/16
Over 54	1/4

Construction Specifications:

1. Reducers: Standard reducers shall provide 5 in. in length for each 1 in. change in diameter.

2. Elbows: Standard elbows of 0-18-in. dia shall be of "Sweep" type; standard elbows of 18-in. dia and over shall be 3-in. "Section Miter." Radius shall be 1 or 1½ x duct dia as specified.

3. Butt Joints: Butt joint strapping shall consist of identical resin used in ducts, combined with glass mat reinforcing and built up to wall thickness. Duct shapes over 18-in. dia or equivalent opening shall be strapped inside and outside. Shapes under 18-in. dia or equivalent opening shall be strapped inside and outside wherever possible to reach interior; where not possible to strap inside, all cut ends shall be liberally coated with identical resin before joining.

Outside and inside strapping shall overlap butt ends a minimum of 1½ in. on duct sizes 0-14 in.; 2 in. on duct sizes 16-30 in.; and 3 in. on duct sizes over 30 in.

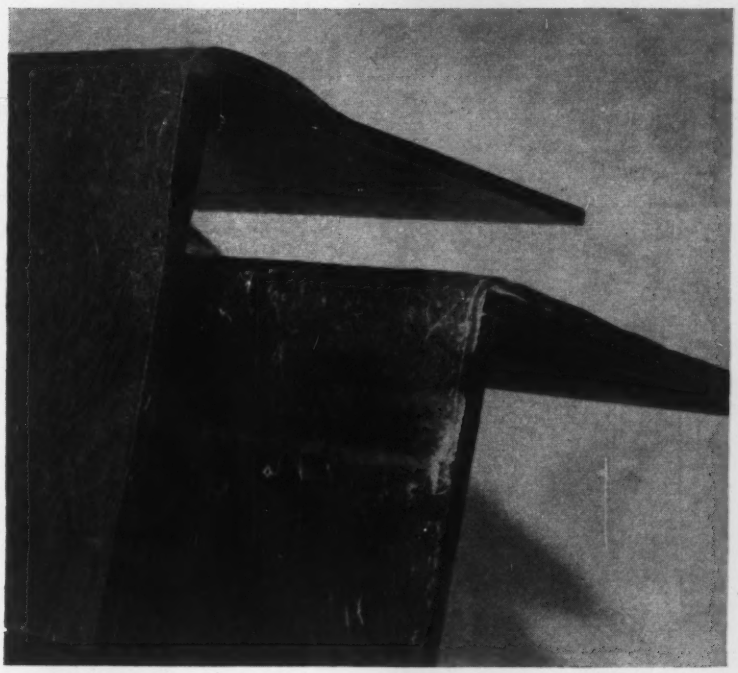
4. Flanges: Flanges shall be integrally attached to body of structure unless otherwise specified.

Flange thickness and width shall be as follows:

FLAT-ROLLED SHEET

Good *End view of acceptable sheet at top shows glass cloth neatly sandwiched between even layers of resin. Also, overall thickness is uniform, there are no voids, and surface is free of pits and blemishes.*

Poor *Size, number and concentration of voids or pits on the sheet at bottom are cause for rejection. End view of laminate shows indications of air entrapment, lack of uniformity, and resin-rich areas.*



CORNER JOINT

Good *Joint at top is filled with resin to provide uniform homogeneous construction with maximum strength. Strapping blends smoothly into sheets, with no indication of air entrapment or drainage.*

Poor *Corner at bottom is improperly butted and has voids that could contribute to structural failure, particularly in high temperature uses. White areas along seams indicate poor adherence of strapping material.*

Duct Opening, in. dia, or equiv	Thk, in. min	Width, in. min
Up to 18	⅜	2
19 to 36	½	2½
Over 36	½	3

5. Physical Properties: Physical properties of the reinforced plastic shall be as follows:[a]

Ten Str (D638), psi ..8,000-12,000
Flex Str (D790), psi 14,000-22,000
Flex Mod (D790), psi ...7-14 x 10^6
Specific Gravity 1.2
Coef of Ther Exp, °F..10.5 x 10^{-6}
Izod Impact Str (D256),
ft lb/in. notch.....30-40
Max Temp Res, F.....220-375

[a] Range given here indicates properties obtainable for various resin and reinforcement systems.

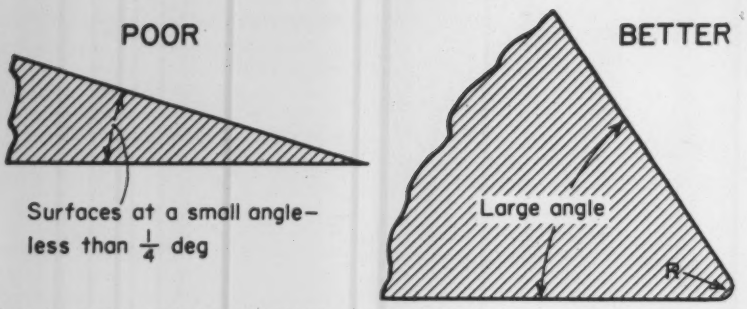
6. Resin: (Specify by tradename, type or grade.)

Other specifications

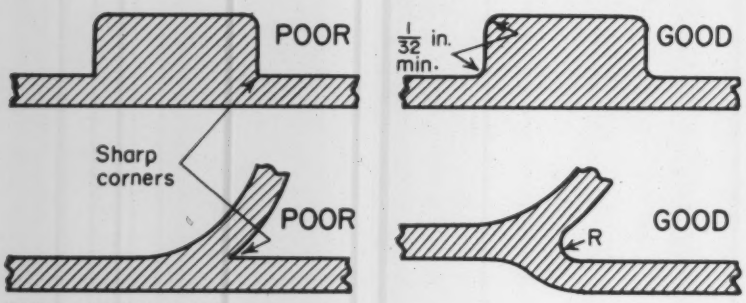
Specifications for other types of equipment, such as processing equipment, may be much more detailed and severe, depending on type of equipment and expected service. Such specifications, should be developed after complete engineering consultation with the equipment fabricator.

For processing equipment, for example, a wide range of types of resins, reinforcement and constructions are available. Typical properties which can be specified for these more critical parts are included in the following property ranges:

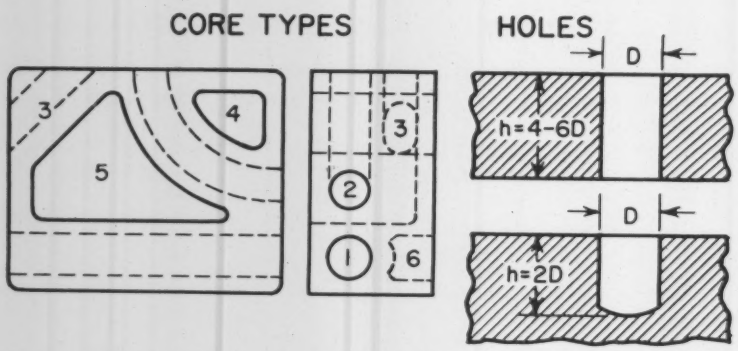
Ten Str (D638), psi ..11,000-15,000
Flex Str (D790), psi .20,000-30,000
Mod of Elast, psi....0.78-1.6 x 10^6
Izod Impact Str (D256),
ft lb/in. notch.....30-40
Specific Gravity 1.4
Coef of Ther Exp, °F....9.5 x 10^{-6}
Standard Color.....Green, gray



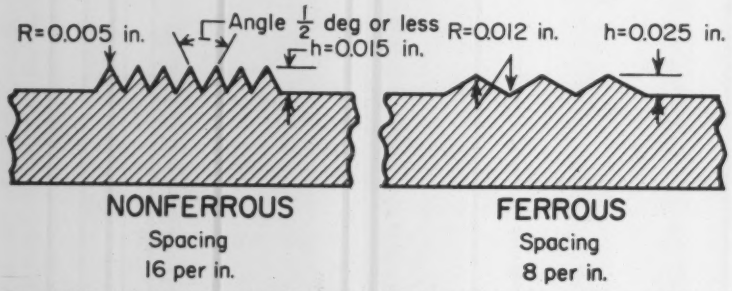
Edges *should be designed with generous radii.*



Fillets *should not be sharp.*



Cores *can enter from any face, at any angle, and can be curved or tapered; six types are shown here. The length of through holes can run up to six times the diameter, but blind holes can be no deeper than twice the diameter.*



Serrations *that can be cast depend on the metal: in low melting metals, 16 per in. are possible; in high melting metals the limit is 8 per in. Dimensions shown here are minimums for the best alloys.*

Design Pointers for Investment Castings

by W. O. Sweeny, *Vice President, Arwood Precision Casting Corp.*

To take full advantage of investment casting, design the part for the process.

Advantages offered by investment castings

Investment casting often offers a means of producing a part at lower cost than the same part can be produced by such processes as stamping or forging. The process is particularly advantageous when:

1. It reduces or eliminates subsequent machining operations.
2. Part performance is improved by using superalloys that are difficult to machine.
3. Redesigning permits replacing several machined parts by one investment casting.
4. Soldering, welding or mechanical fastening is undesirable.
5. Small quantity production is desirable to prove a design before undergoing an extensive tooling program for long-run production.

However, the part must be designed properly to take full ad-

Investment castings: many materials, many uses

1, indicia stamp *for postal equipment—1020 steel.* ***2, actuating cam*** *for printing machiners, 4140 steel.* ***3, landing gear lever*** *for helicopter, 17-4PH stainless steel.* ***4, valve housing,*** *316 stainless steel.* ***5, automatic pilot frame,*** *red brass.* ***6, reel support*** *for tape recorder, 440C stainless steel.* ***7, screw*** *for diesel engines, 310 stainless steel.* ***8, re-inker tank*** *for computing machine, manganese bronze.* ***9, fitting*** *for pressure-tight hydraulic system, S monel.* ***10, numbering wheel*** *for register, beryllium copper.* ***11, cooling reactor*** *for missile, 356 aluminum.* ***12, rotor*** *for flow meter, magnesium.*

Tolerances on . . .

TABLE 1—Straightness

Length, in.	As Cast[a], in. ±	Straightened[a], in. ±
Up to 2	0.010	0.005
2-4	0.015	0.010
4-6	0.020	0.010
Over 6	0.030	0.015

[a]Full indicator reading.

TABLE 2—Flatness

Length, in.	As Cast, in. ±	Straightened, in. ±
1	0.008	0.004
2	0.016	0.006
4	0.025	0.010
6	0.030	0.015

TABLE 3—Parallelism

Distance Between Sections, in.	As Cast, in. ±	Straightened, in. ±
1/16	0.003	0.003
1/8	0.003	0.003
1/4	0.003	0.003
1/2	0.005	0.004
3/4	0.006	0.004
1	0.007	0.005
1 1/2	0.010	0.007

TABLE 4—Concentricity

Outside Dia, in.	Inside Dia, in	As Cast[a], in.	Straightened[a], in.
3/4	1/4	0.004	0.004
1	1/2	0.005	0.005
1 1/2	3/4	0.008	0.005
2	1	0.010	0.008

[a]Full indicator reading.

vantage of the investment casting process. Generally, the same basic design rules applicable to other casting processes can be followed. However, greater emphasis can be placed on designing to do the job than on designing for subsequent finishing operations. In many investment castings, machining is required only for critical dimensions; surface finishes obtainable as cast range from 125 μ in. rms on ferrous castings to between 63 and 100 μ in. rms on nonferrous castings.

Suggested tolerances, radii

Curved and blended contours produce stronger designs than straight lines and abrupt angles, and are usually less expensive. However, straight lines and sharp angles can be produced if they are required for the functioning of the part.

For dimensions that are not critical, generous casting tolerances are most economical. Although a casting tolerance of ±0.005 in. makes it possible to produce low cost castings, tolerances of ±0.010 in. are even better. Minimum tolerance is about 0.003 in. on any dimension less than 5/8 in. Tolerances on specific dimensions are discussed briefly in the following paragraphs.

Minimum section thickness—The geometry of the part is the basic factor but the material being cast also influences the minimum thickness that can be cast. In low melting alloys, small or tapered areas can be held to a thickness of 0.020 in., large areas to 0.040 in. In high melting alloys, thickness must be increased. Small or tapered areas can be held to 0.030 in., large areas to 0.060 in.

Straightness—Long thin parts must be mechanically straightened to obtain a high degree of straightness. As-cast and straightened tolerances are given in Table 1.

Flatness—In typical flat sections, bow, twist and waviness must be removed by mechanical straightening. Typical tolerances are given in Table 2; although developed for flat rectangular castings, these tolerances can be applied to any flat part regardless of irregularity of shape.

Parallel sections—Parts with parallel sections can be held to ±0.005 in. per in., although machine straightening may be required for long shapes. Tolerances that can be held as cast and after straightening are given in Table 3.

Angles—Generally angular tolerances can be held to ±1/2 deg.

Radii and fillets—The minimum edge radius is 0.007 in. for nonferrous metals, 0.012 for ferrous metals. Fillets of 1/32 in. are desirable but even as little as 0.005 in. is helpful because sharp corners should be avoided as much as possible.

Roundness—Diameters can be held to ±0.005 in. per in. Tubular parts can be held to closer tolerances by machine straightening.

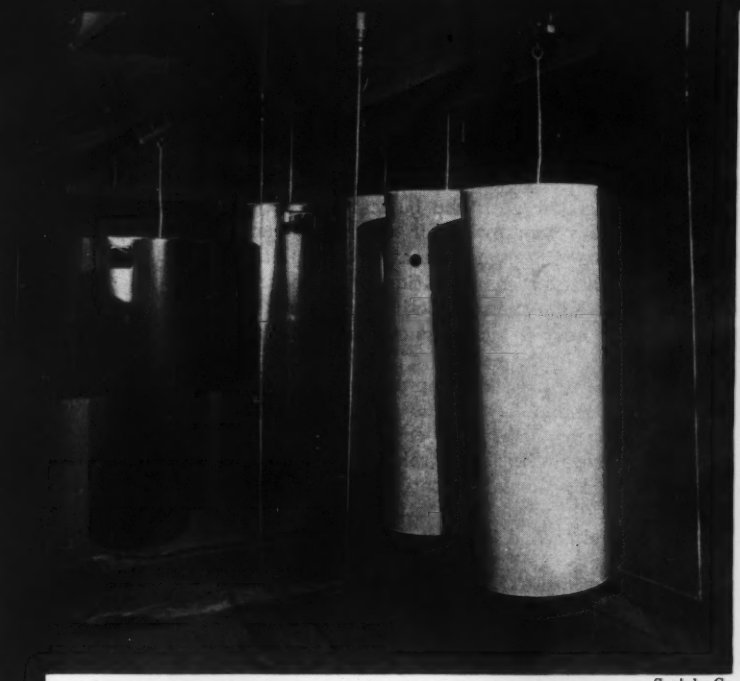
Concentricity—In general, the larger the outside diameter, the more concentric (proportionally) the inside diameter can be. In addition, large diameter parts are easier to straighten than small diameter parts. Table 4 gives tolerances for as-cast and straightened parts.

Holes—Minimum core size is 0.030 in. for nonferrous metals, 0.050 in. for ferrous metals; holes can be held to ±0.005 in. per in. Tapered holes can be formed without difficulty if they are tapered inward from their mouths. Intersecting holes can be formed but the design should be laid out to permit withdrawal of cores.

Materials

A wide variety of ferrous and nonferrous metals can be investment cast. Ferrous metals include carbon and low alloy steels, tool steels, austenitic, martensitic and precipitation hardenable stainless steels. Nonferrous metals include the standard aluminum casting alloys, magnesium alloys, leaded and nonleaded brasses, bronzes, nickel alloys and cobalt alloys.

Alloy selection is an important consideration. A major advantage of investment casting is freedom of choice of alloy, and selection based on metal cost throws this advantage away. Pick the most suitable alloy for your purpose regardless of cost. The amount saved by using a lower cost material will amount to only a few cents per casting.



Sealube Co.

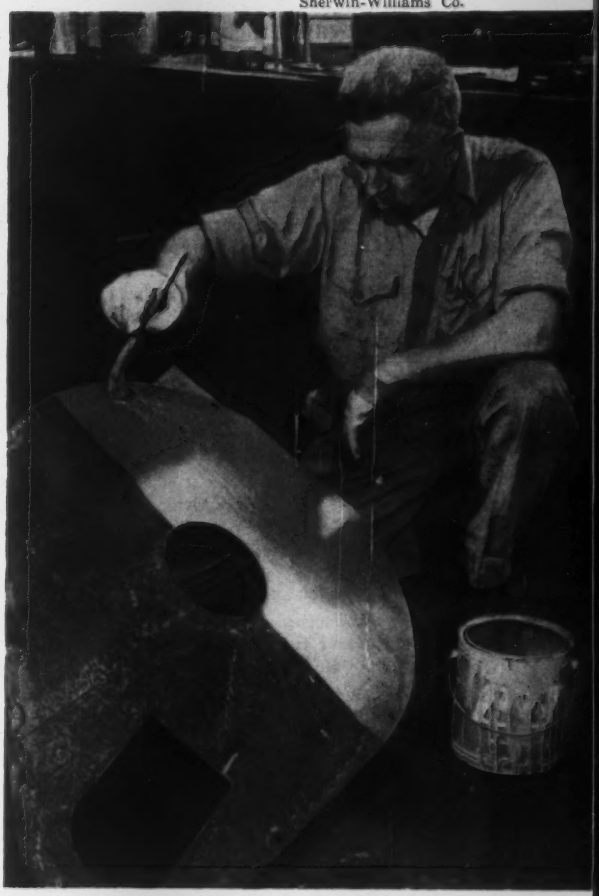
Spraying *heater jackets electrostatically.*

Dow Chemical Co.

Dipping *a car body.*

Brushing *a water valve part.*

Sherwin-Williams Co.



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Organic Coatings for Metal Products

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

Choosing from among the many thousands of coating formulations is a lot easier when you are familiar with the characteristics of the principal groups to which they belong. This manual gives the important types, their properties and uses.

Alkyds
Ureas and melamines
Acrylics
Bitumens
Cellulosics
Coumarone-indenes
Epoxies
Fluorocarbons
Phenolics
Polyamides
Rubbers
Silicones
Styrene-butadienes
Urethanes
Vinyls

■ The broad term organic coatings encompasses materials commonly called paints, varnishes, lacquers, enamels and emulsions. Such terms do not tell us much about the engineering properties and uses of the coatings to which they refer. This manual, therefore, is concerned with organic coatings as *basic chemical types*—alkyds, phenolics, vinyls, etc., including combinations of these types. Each chemical type, so called after the major resin or other constituent, offers a certain range of performance properties as a dry film—and it is these properties which primarily concern the engineer and designer.

With some exceptions, the various chemical types of coatings are arranged in alphabetical order in this manual. The table on pp 116-117 gives a point-by-point comparison of the various types.

Selecting coatings by chemical type has certain limitations. For one thing, the properties normally associated with the basic resin may be altered to some extent by minor resins, pigments, plasticizers and modifiers in the coating formulation. In addition, production considerations may be more important than end performance in some cases; if so, it may be necessary to limit the choice to coatings suitable for a particular method of application and curing, e.g., dipping instead of spraying, and air drying instead of baking.

Such factors are considered in this manual, but space limitations prohibit detailed discussion. In selecting organic coatings it is usually advisable to consult with the coating formulator from the beginning, and to conduct at least limited service tests.

Alkyd

coatings are more widely used on metal products than any other coating system. The coatings are characterized by their comparatively low cost, excellent color retention and exterior durability, good gloss, and fair resistance to water and alkalis.

Because of their almost ideal combination of properties, alkyd resin coatings are extremely popular for protecting and decorating metal surfaces. A wide variety of air drying and baking coatings have been developed to take advantage of these properties and it is difficult to make a logical breakdown of available types. However, in very general terms, the coatings can be classified into: oil-modified alkyds, resin-modified alkyds, and alkyd emulsions.

Oil-modified alkyds

Most alkyd resins for coatings are made from phthalic anhydride plus glycerin or pentaerythritol, plus drying or semi-drying oils or their fatty acids. The amount and type of oil used has a marked effect on coating properties. Many variations are used, and the ratio of phthalic anhydride to fatty acids varies widely. In general, the various oil-modified alkyds are referred to as short, medium or long-oil alkyds. A short-oil alkyd contains roughly 40 to 50% phthalic anhydride; a medium-oil alkyd 30 to 40%; and a long-oil alkyd about 20 to 30%.

Short or short-medium-oil length alkyds are noted for their excellent color retention, toughness and adhesion. The principal alkyd resins available in this category are:

1. A short-oil oxidizing alkyd designed for use with urea or melamine formaldehyde (amino) resins for fast baking finishes with good color properties.

2. A short-oil oxidizing alkyd designed for fast air drying or baking. Color retention of this alkyd is not as good as for others, and an amino resin must usually be added for maximum hardness. The alkyd-amino coating has very high resistance to humidity and salt spray and can be used as an alkali resistant coating for washing machines.

3. A short-oil oxidizing alkyd which has very fast initial set and excellent air drying properties. This alkyd can be combined with other alkyd or amino resins. One formulation, with high initial gloss, gloss retention and durability, can be used as a vehicle for automotive baking enamels. Other formulations are used on exterior metal signs, kitchen cabinets and hospital equipment.

4. Short non-drying-oil-modified alkyds which, among other purposes, are designed for formulating melamine formaldehyde resin baking enamels with good color properties at elevated temperatures. The coatings are suitable for continuous use at 200 F without significant discoloration and can be used intermittently at much higher temperatures.

Medium-oil-length alkyds modified with soya or linseed oil are primarily intended for sprayable air drying enamels, but they can be used for baking and brushing enamels. Some principal resins available in this group are:

1. A medium-oil oxidizing alkyd with fast drying properties. This alkyd can be used with or without amino resins and is particularly well suited for fast drying gasoline pump and auto refinishing enamels, and for fadeproof white enamels.

2. A medium-oil oxidizing alkyd that air-dries extremely fast and has excellent toughness, flexibility, and exterior gloss retention and durability. It also has good resistance to oils, gasoline, water, alkalis and salt spray. It can be baked quickly, especially when combined with amino resins. This alkyd is used in auto and machinery enamels and a wide range of industrial finishes.

3. A medium-oil oxidizing alkyd, soluble in mineral spirits, which combines fast drying and good color retention. It is widely used in air drying primers because of its adhesion, toughness and durability. It is frequently combined with amino resins for added hardness and mar resistance.

Long-oil soya alkyds are designed principally for interior and exterior architectural enamels and for marine finishes. One of the principal alkyds in this group for metal surfaces is a long-oil, oxidizing alkyd of the pentacrythritol type. This is an air drying enamel which is ideal for marine finishes because of its combination of good color properties and resistance to water, salt spray and cleaning compounds.

In general, air drying long-oil alkyds are more widely used for maintenance purposes than any other coating. In addition to their good protective properties, they are

low in cost and can be used where baking is not practical. Of course, these coatings do not have the properties of baked coatings, but they are much superior to oil paints and varnishes.

Resin-modified alkyds

Conventional oil-modified alkyd coatings have an excellent range of properties. However, as with most other coatings, some properties can be improved still further by modifying the alkyds with other coating resins.

Alkyd-phenolic coatings were developed primarily to improve the resistance of oil-modified alkyds to water and chemicals. This gain in properties is made at the expense of poorer flexibility, impact resistance, and color and gloss retention. However, these disadvantages may not be important if high water and chemical resistance is needed, as in the interiors of washing machines and chemical process tanks.

Alkyd-vinyl combination coatings are designed to shorten the drying time of short and medium-oil-length alkyd resins and to increase their toughness and chemical resistance. A typical corrosion inhibiting primer consists of about 10% vinyl resin and 90% medium-oil alkyd resin. This primer dries in about 4 hr; about 8 hr would be needed if the vinyl were not used.

In general, an alkyd-vinyl coating is more flexible than a straight alkyd. For this reason, the coatings have been used to precoat metals before they are fabricated into such items as caps, closures and novelties.

Alkyd-silicone coatings have much better resistance to heat than straight alkyds. Copolymerization actually takes place between the alkyd and silicone resins and the blend is not a mechanical one. As pointed out later in the section on silicone coatings, the amount of silicone resin in such blends may vary from just a trace to almost 100%. The presence of a small amount of silicone resin in an alkyd coating tends to improve gloss and color retention. As silicone content is raised, and aluminum or graphite pigments are added, the resulting coating tends to have better durability and resistance to heat and salt spray. Some high silicone coatings can be used to over 1000 F. Actually, the organic alkyd decomposes in use and the end coating consists of a silicone matrix combined with the aluminum or graphite pigment.

Lion Oil Co.

***Chemical tank car** is provided with bituminous coating to prevent corrosion by spilled chemicals and outdoor weathering.*

Some 50-50 alkyd-silicone baking coatings will retain their color up to 350 F. One gray enamel developed to meet a U. S. Navy specification can withstand 700 F for 24 hr.

Styrenated alkyd coatings were developed mainly to take advantage of polystyrene's good color retention, toughness, and resistance to water and alkalis. In these respects styrenated alkyds are superior to pure oil-modified alkyds; however, they are not as durable on exterior exposure.

Styrenated alkyd coatings can be baked or air dried. The time required for air drying is usually quite low. For this reason styrenated alkyds are suitable for fast air drying finishes on products such as toys and metal furniture. They can also be used for interior surfaces which must resist alkali cleaning solutions but are not subject to oil or grease contact. In general, the baked coatings have better resistance properties, particularly when they are combined with amino resins.

Alkyd emulsions

The principal advantage of alkyd emulsions, i.e., water-thinned coatings, is that they do not contain any inflammable constituents and can be used with complete safety. However, their noninflammability is obtained at the expense of certain other properties. In order to produce an emulsion certain agents must be added to the coating which generally tend to degrade film properties. Thus, an emulsion may not have as good properties—particularly outdoor durability and gloss retention—as conventional solvent-type alkyds. Also, since alkyd emulsions are generally suitable only as primers it may be necessary to use an inflammable, solvent-type topcoat which can completely negate the advantage of using a noninflammable primer.

Alkyd emulsions can be air dried, but improved properties are obtained by baking. A short drying period is required before baking to prevent pinholing, and this may interfere with production schedules.

Alkyd emulsions have proved valuable as shop coatings to prevent corrosion. They are useful in shop operations where only one coat is required and where safety precautions would be difficult to observe. A typical example is their use in foundries on hot castings to prevent corrosion.

HOW ORGANIC COATINGS COMPARE[a]

Type →	Alkyd			Acrylic	Bitum-inous	Cellulose		Epoxy		
	Alkyd	Alkyd-Amine	Styrenated Alkyd			Nitro-cellulose	Butyrate	Epoxy (100%)	Epoxy-Urea	Epoxy-Ester
CHEMICAL RESISTANCE										
Exterior Durability	E	E	G	E	E	E	E	G	G	G
Salt Spray	E	VG	G	E	E	E	E	E	VG	E
Solvents—Alcohols	F	G	G	G	P	G	G	E	E	VG
Solvents—Gasoline	G	E	E	G	P	G	G	E	E	E
Solvents—Hydrocarbons	G	E	E	F	P	F	F	E	E	VG
Solvents—Esters, Ketones	P	P	P	P	P	P	P	F	VG	F
Solvents—Chlorinated	P	P	P	P	P	P	P	E	E	F
Beverages, Food	F	G	VG	VG	E	P	G	E	E	VG
Salts	VG	E	E	VG	E	G	VG	E	E	E
Ammonia	P	P	P	P	—	P	P	P	P	P
Alkalis[b]	G, G	VG, G	G, VG	G, F	E	P, P	P, P	E, E	E, E	E, E
Acids—Mineral[c]	F, P, P	G, F, P	G, F, P	G, F, P	E, –, –[k]	G, F, P	G, F, P	E, VG, G	E, VG, F	G, F, P
Acids—Oxidizing[c]	P, P, P	F, P, P	F, P, P	F, P, P	—	P, P, P	P, P, P	G, P, P	F, P, P	F, P, P
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	P, P, P	P, P, P	E, –, –[l]	P, P, P	P, P, P	G, F, P	F, P, P	F, P, P
Acids—Organic (oleic, stearic, etc.)	F	G	F	F	E	F	F	E	E	E
Acid—Phosphoric	P	P	P	P	E	P	P	P	P	P
Water (salt, fresh)	F	G	G	E	E	F	E	VG	G	VG
PHYSICAL PROPERTIES										
Sward Rocker Hard. (8th day)	24	30	28	24	—	26	26	36	34	30
Flexibility	E	VG	G	E	E	E	E	E	VG	G
Abrasion Res, cycles[d]	3500	>5000	>5000	2500	—	2500	2500	>5000	>5000	>5000
Max Svc Temp, F	200	250	200	180	300	180	180	400	400	300
Toxicity	None	Slight	Slight	None	—	None	None	Slight	Slight	Slight
Impact Res	VG	E	G	E	E	E	E	G	G	E
Heat Res[c]	G	VG	G	P	G	P	P	VG	VG	G
Dielec Properties	G	G	G	VG	—	P	G	VG	VG	VG
Adhesion to—										
Ferrous Metals	E	E	E	VG	E	VG	VG	E	E	E
Nonferrous Metals	F	E	E	VG	E	G	G	E	E	VG
Old Paints	VG	G	VG	P	—	P	P	P	P	F
DECORATIVE PROPERTIES										
Choice of Colors[f]	U	U	U	U	L	U	U	SL	SL	SL
Color Retention	G[e]	VG[e]	G[e]	E[e]	—	E[e]	E[e]	G[e]	G[e]	E[e]
Initial Gloss	E	E	E	E	P	E	E	VG	VG	E
Gloss Retention	E	G	G	E	—	VG	E	F	F	G
APPLICATION										
Ease of Application	E	Bake req	E	VG	P–VG	VG	VG	Catalyst req	Bake req	E
Metal Surface Prep	Primer	No primer	No primer	Primer	No primer	Primer	Primer	No primer	No primer	Primer
Solvent for Appl[h]	Hyd	Hyd	Hyd	Blend	—	Blend	Blend	Ketone	Blend	Hyd
Methods[f]	U	U	U	U	L	U	U	L	L	U
Cure[i]	A or B	B	A or B	A	A	A	A	A	B	A or B
Bake Drying Time[j]	30 min (275 F)	20 min (320 F)	15 min (300 F)	—	—	—	—	—	30 min (350 F)	30 min (320 F)
Air Drying Times										
Touch	2 hr	—	10 min	5 min	2 hr	5 min	5 min	45 min	—	1 hr
Handle	4 hr	—	30 min	15 min	24 hr	15 min	15 min	2 hr	—	2 hr
Re-Coat	4 hr	—	4 hr	15 min	—	15 min	15 min	6-8 hr	—	8 hr
Hard	12 hr	—	4 hr	12 hr	24 hr	12 hr	12 hr	12 hr	—	8 hr
Corr Res	48 hr	—	48 hr	24 hr	—	24 hr	24 hr	7-10 days	—	5 days
Coverage, sq ft/gal/mil	450	450	400	350	Low	200	200	450	500	450
Coat Thk (avg), mil	1.5	1.5	1.5	1.0	30–250	1.0	1.0	1.8	1.8	1.5
Cost, ¢/sq ft/mil dry[m]	1.50	1.75	1.75	2.75	—	2.50	2.75	—	2.00	1.75

[a] The major part of these data was supplied by Howard Rothenberg of Protective Coatings, Inc. The data are intended only as a preliminary selection guide. Final selections should be made after consulting with coating formulator. Space limitations prevent inclusion of data for all formulations of a particular resin as well as data on some of less widely used materials. For additional data see text and "Organic Coatings," *M/DE Materials Selector*, Mid-Oct, '58, p 267. Key: = excellent; VG = very good; G = good; F = fair; P = poor.

[b] Two ratings are for dilute (<20%) and concentrated, respectively.

[c] Three ratings are for dilute (<10%), medium (10-30%) and concentrated, respectively.

[d] Taber GS-10 wheel.

[e] In general, E = 700-1000 F; VG = 550-700 F; G = 200-300 F; P = 200 F.

[f] L = limited (pure white cannot be formulated); SL = sligtly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).

Fluorocarbon (air dried)	Phenolic	Polyamide (nylon)	Rubber: Chlorinated Rubber	Rubber: Neoprene	Rubber: Hypalon	Silicon	Urethane	Vinyl
E	E	P	E	E	E	E	E	E
E	E	F	E	E	E	E	E	E
F	E	G	F	E	—	P	F-G	E
F	E	G	G	F	P	VG	F-G	E
P	E	—	P	P	—	VG	F-E	G
P	E	—	P	G	—	P	F	P
P	G	—	P	P	—	P	P	P
E	E	—	G	F	—	P	VG	E
E	E	—	E	E	—	G	E	E
E	P	G	VG	E	E	P	P	E
E, E	P, P	G, G	VG, F	E, E	—	P, P	VG, F	E, E
E, E, E	E, E, E	P, P, P	E, G, P	E, G, P[k]	E, E, E	G, P, P	G, F, P	E, E, G
E, E, E	E, E, VG	—	E, E, P	G, F, P	—	P, P, P	G, F, P	E, VG, G
E, E, E	G, F, P	P, P, P	G, P, P	P, P, P	—	P, P, P	G, F, P	E, P ,P
E	E	VG	E	F	—	P	F	E
E	F	—	G	VG	E	P	F	E
E	E	F	VG	E	E	E	E	E
20	38	—	24	< 10	—	16	35-65	20
G	G	G	VG	E	E	F	E	E
1000	>5000	—	>5000	5000	—	2500	>5000	>5000
212	350	300	250	200	250	1200	300	180
Slight	None	—	Slight	None	—	Slight	Slight	None
E	G	VG	G	E	E	G	E	E
E	G	G	P	G	G	E	G	P
E	E	G	E	F	VG	E	E	E
VG	E	VG	F	VG	VG	G	E	VG
VG	E	VG	VG	VG	VG	F	E	VG
P	G	—	E	—	—	E	F	G
U	L	L	L	L	U	U	U	U
G[g]	P[g]	—	G[g]	G	E	G[g]	G	VG[g]
E	VG	G	F	P	P	E	E	G
F	F	—	F	F	—	E	P	F
VG	E	G	E	VG	VG	E	E	VG
Primer	No primer	No Primer	Primer	No primer	No primer	Primer	Primer	Primer
Blend L	Alc U	— L	Hyd U	Hyd U	Hyd U	Hyd U	Blend U	Blend L
A or B	A or B	A	A or B	A or B	A	A or B	A or B	A or B
15 min (300 F)	30 min (350 F)	—	15 min (300 F)	15 min (300 F)	15 min (300 F)	1 hr (400 F)	30 min (325 F)	15 min (300 F)
5 min	10 min	—	45 min	15 min	15 min	45 min	45 min	15 min
15 min	30 min	—	2 hr	30 min	30 min	2 hr	1-2 hr	30 min
12 hr	30 min	—	4-6 hr	4 hr	4 hr	4-6 hr	4-6 hr	4-6 hr
12 hr	4 hr	—	4-6 hr	4 hr	4 hr	12 hr	18 hr	4-6 hr
12 hr	24 hr	—	24 hr	7-10 days	7-10 days	12 hr	5-7 days	24 hr
200	350	—	450	300-400	250-350	350	—	250
1.0	1.5	2-30	1.5	2-10	2	1.0	1-2	1.0
15.00	1.75	—	1.50	—	—	6.00	—	2.50

[g] Based on white coatings with titanium dioxide pigment.
[h] Hyd = hydrocarbons; alc = alcohols.
[i] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.
[j] Full corrosion resistance is obtained immediately upon cooling.
[k] Not recommended with nitric acid.
[l] Not recommended with strong solutions of acetic acid.
[m] Based on high quality formulations; figures are meant to serve only as a rough guide.

Urea and melamine formaldehyde

coating resins are usually used with other resins to produce an improved combination of properties. They are instrumental in improving alkali resistance and hardness, and in reducing wear, baking time and color fading.

Urea and melamine formaldehyde resins (sometimes referred to as amino resins) are not suitable for use alone, but are usually used in large proportions with other coating resins to improve their properties. When used alone they produce hard, almost colorless films which, unfortunately, are quite brittle and have poor adhesion when baked. However, when used with other coating resins, particularly the alkyds and epoxies, they provide a good combination of properties. When used with alkyd resins they provide much better mar and scratch resistance than alkyds alone. Depending on the application, the amount of amino resins used in combination coatings can vary from 5 to as high as 50%.

Amino resins are often used with oxidizing-type alkyds to shorten baking time and to raise the hardness and alkali resistance of the coatings. They are also used with non-oxidizing alkyds for white baking coatings to obtain maximum whiteness and to improve the retention of color with heat and aging.

In general, coatings based on urea formaldehyde or melamine formaldehyde resins are baked at about the same temperature. However, the melamine coatings usually bake to the same hardness as urea coatings in considerably less time at a given temperature. Thus, lower concentrations of melamine resins can be used to provide the same hardness under the same baking conditions. Or, for equal concentrations of melamine and urea resins, the melamine resin coating cures quicker and at a lower temperature. When baked to the same hardness, the mar and wear resistance of the melamine and urea coatings are about equal.

Melamine-based alkyd coatings generally have better heat resistance than urea-based alkyd coatings. Melamine formaldehyde resins can withstand temperatures of 450 F to the same degree that urea formaldehydes will withstand 300 F.

The resistance of melamine-based

Shell Chemical Corp.

Pharmaceutical seed tank *is provided with epoxy coating to protect metal against corrosive influences of steam and water.*

alkyd coatings to water, alkalis and solvents is equal to, and in many cases superior to, that of urea-based alkyd coatings. The durability of some melamine-alkyd coatings is superior than straight alkyds and the melamine-alkyds have the added advantage of greater hardness and chemical resistance.

Color retention of melamine and urea-based alkyd coatings are about the same at baking temperatures up to 300 F. However, a melamine-based coating should be used if higher baking temperatures are required. The melamine-based coatings have better color retention on stoves and lighting fixtures that are subject to high temperatures for long periods.

The amino resins are well suited for coatings for consumer products because of their absence of color, non-yellowing properties, and ability to reduce baking times and improve hardness. They are widely used in a number of different formulations developed especially for general appliances, refrigerators, washing machines and heating appliances. They are also used in coatings for automobiles, toys, bicycles and many other products.

Acrylic

coatings provide high decorative appeal and are tough and durable, particularly in outdoor applications. They are also resistant to dilute acids, alkalis and mineral oils.

Acrylic coatings are based on a class of polymers or synthetic resins known as acrylic and methacrylic esters. These polymers (related to Plexiglas and Lucite) produce coatings that are tough and durable in outdoor as well as indoor applications. Acrylic coatings for metal products are used mainly in the form of clear coatings or as pigmented enamels.

Clear coatings

Clear acrylic coatings have good resistance to dilute acids, alkalis and mineral oils. However, they are readily soluble in strong solvents such as ketones and esters, and soluble to a lesser degree in aromatic hydrocarbons. The coatings are thermoplastic and become tacky when exposed to temperatures of about 200 F, but they recover their original hardness upon cooling. Clear acrylic coatings cure by air drying and do not have to be baked. Low temperatures reduce the flexibility of the coatings but do not cause any permanent damage. They cost somewhat more than conventional oil or alkyd-base coatings.

Clear acrylic coatings are especially useful in protecting polished metals because of their invisibility and their resistance to atmospheric fumes and moisture. They provide excellent protection for brass and bronze parts which tend to dull rapidly, and for silverware such as candlesticks, trophies and plaques. They also prevent staining of aluminum window and door frames, curtain walls and similar products by mortar, plaster and stucco.

Protective as well as decorative clear acrylic coatings can be used on aluminum foil. If required, the coatings may be treated with transparent dyes for novelty effects. Both clear and pigmented coatings are used in vacuum metallizing. A clear acrylic base coat provides a smooth undercoat for the metallized layer. An acrylic topcoat over the metallized layer, in addition to providing abrasion resistance, can be used to change the color of the finish.

Enamels

Since they do not react with conventional paint pigments and metal powders, acrylic polymers can be used to produce a wide range of colored enamels. Acrylic resin solutions mixed with powdered aluminum, bronze or stainless steel, are easy to use and provide a simulated metal surface that is highly brilliant.

Acrylic coatings are becoming a major factor as a replacement for conventional nitrocellulose lacquers on some automobiles. Indications are that they can be made in a wider variety of colors and that they have better gloss and color retention than previously used coatings.

Acrylic enamels are widely used on machinery and equipment exposed to chemical fumes and fruit juices. Modification with chlorinated rubber provides an unusually tough and resistant coating. Modified acrylics can also be used to provide a tough, adherent, flexible coating which can be applied to sheet metal before fabrication. Acrylic enamels modified with silicone polymers can protect parts operating at 300 to 500 F.

Water-thinned coatings

There has been a good deal of experimentation with noninflammable, water-thinned acrylic primers and topcoats for metal products. Limited commercial use has been made of water-thinned primers which, when baked, provide good salt spray resistance, adhesion, and toughness. Small quantities of water-thinned topcoats are also being made. A wire enamel based on an acrylic emulsion is also on the market. In addition to their noninflammability, these coatings are said to have excellent gloss, color retention, impact resistance and hardness. However, there are still some problems to be worked out, particularly foaming during application, "crawling" over greasy metal, and the need for a short drying period before baking.

Bituminous

or asphalt coatings are highly resistant to water, chemicals and outdoor exposure. They are tough and adherent, and when suitably modified provide good thermal insulation.

Bituminous coatings are one of the oldest types of coatings known. Because of their excellent resistance

to a wide variety of media they are still quite popular today. However, because of their comparatively poor appearance they are usually used for protective rather than decorative applications.

Coal tar pitches

These coating materials are produced upon distillation of coal tars. Pitches can be classified as soft, medium or hard, and some grades may be used directly as hot melt coatings for protecting underground pipes, water tank interiors, etc.

Solvent-type coatings

A number of asphalts and pitches can be combined with volatile solvents to produce coatings that dry by solvent evaporation. These coatings can, if required, be combined with a variety of other coating resins, such as natural resins, phenolics, alkyds and urea formaldehyde.

Typical of the coatings available is one made from solvent cutbacks of a selected asphalt base and containing asbestos and other mineral fillers. Upon solvent evaporation the coating cures to a highly weatherproof, tough, adherent film. It can be applied to metals to protect them from moisture and from atmospheres containing dust and corrosive chemicals. The coating is not resistant to oils, greases and asphalt solvents; however it is highly impermeable to water and can be used under conditions of intermittent or total immersion. This type of coating has proved popular for protecting metal buildings and roofs, barges, pontoons, storage and tank cars, and industrial piping.

Also available are asphalt-base mastic coatings which contain a large amount of screened ground cork and small quantities of asbestos. These coatings cure to tough, abrasion resistant films which are usually used where combined thermal insulation and weather and vapor protection is required. Typical uses include storage tanks, ducts, pipelines, and bodies for trucks, buses and railway cars.

Bituminous emulsions

Bituminous emulsions, containing 40 to 50% asphalt dispersed in water, are available. They can be used in relatively thick coatings for protecting metals but, in general, their properties are not as good as those of solvent-type coatings. However, they can be improved by incorporating inhibiting pigments such as red lead.

Cellulosic

coatings dry quickly in air, are tough, and have good film strength. Clear coatings provide excellent appearance indoors; pigmented coatings for outdoor use have high durability, gloss and color retention.

A number of cellulosic materials can be used in protective and decorative coatings for metal products. Some do not have very good initial properties, but their excellent compatibility with other coating resins makes it possible to produce blends with vastly improved properties. Following are the most important types:

Nitrocellulose

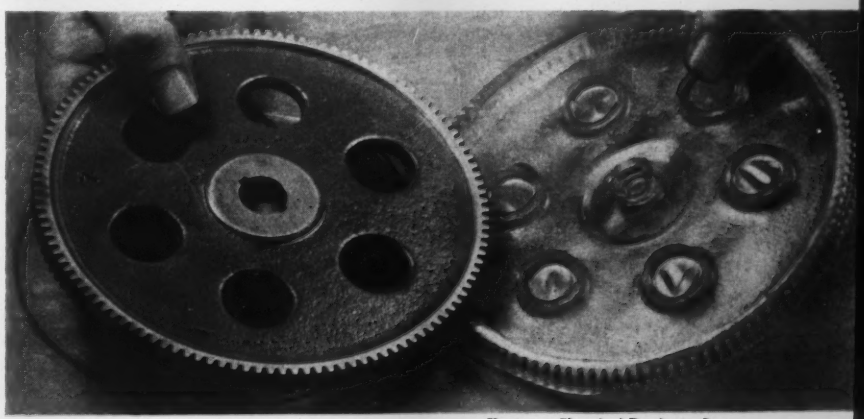
Nitrocellulose, or cellulose nitrate, is more widely used than any other cellulosic material for coating metal products. Because of its fast drying properties it is especially useful for finishing products quickly and in large quantities. Since nitrocellulose coatings dry dust-free in just a few minutes, they can reduce the time, space and equipment required for curing and baking. The coatings are sometimes force dried at about 150 to 180 F to improve their hardness and polishing properties (as in the case of automotive lacquers).

Nitrocellulose coatings are available in either clear or pigmented form. Clear nitrocellulose lacquers are widely used on metal novelty goods and art objects to prevent tarnishing. These lacquers do not react with the base metal, have good adhesion, are pale in color and are non-yellowing. However, they have poor resistance to exterior degradation and must usually be used indoors. Pigmented nitrocellulose lacquers have excellent color properties outdoors since the pigments tend to absorb ultraviolet light. However, not all pigments are good light absorbers, and tests should be made if color retention is important.

In general, unmodified nitrocellulose does not have very good resistance to heat and light, and is quite flammable. However, these properties can be improved considerably through modification. Modifying resins help to improve the gloss of nitrocellulose lacquers and, because of their lower viscosity, make for greater solids content and thicker coatings. Some resin additions, such as rosins, acrylics and vinyls, are mainly used with nitrocellulose for furniture and fabric coatings.

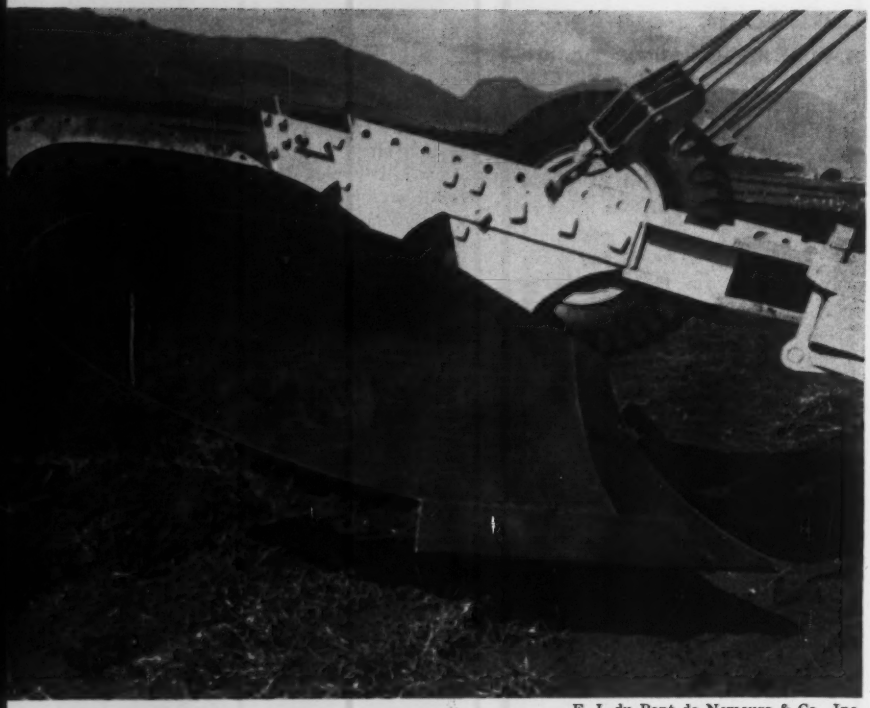
The most important modified types available for metal products are:

Nitrocellulose–natural resins—Until the advent of synthetic resins, natural resins were widely used to improve the properties of nitrocellulose lacquers. Some natural resin modifiers, such as dammar, shellac, elemi, mastic and pontianak, are still being used. Dewaxed dammar has a pale color and can be added to nitrocellulose to improve adhesion and polishing properties. Dewaxed and bleached shellac can be added to improve adhesion and gloss. Similary, gum demic can be added to nitrocellulose lacquers to improve adhesion.



Eastman Chemical Products, Inc.

Gears *and many other small mechanical parts can be protected during storage and handling by a thick cellulose acetate butyrate coating which is dip-applied and can be easily stripped off.*



E. I. du Pont de Nemours & Co., Inc.

***Plows** are being experimentally coated with Teflon which has low friction and excellent "anti-sticking" properties. Coated plows used in Hawaiian soil have cut plowing time in half and enabled tractors to operate in a higher gear. Tests are being conducted in this country, but wear may be a problem because of higher sand content of soils.*

Nitrocellulose – alkyd resins — In general, oxidizing types of alkyd resins tend to produce lifting when used with nitrocellulose. However, some oxidizing resins can be tolerated for one-coat application, or if they are used in small quantities in multiple coats. A non-oxidizing, short-oil alkyd is frequently used with nitrocellulose lacquers to improve their durability. This type of alkyd is pale in color, non-yellowing, and can be used in white lacquers and for automotive finishing lacquers. In general, a long-oil, oxidizing type of alkyd causes lifting. Additions of medium to short-oil oxidizing alkyds produce excellent nitrocellulose coatings, but they are usually only suitable for one-coat application if lifting is to be avoided.

Nitrocellulose–amino resins — Because of their heat-convertible properties, amino resins are not ordinarily used with air drying coatings such as nitrocellulose. Nevertheless, it has been shown that small quantities of melamine formaldehyde can improve the gloss retention and water-spot resistance of automotive lacquers.

Cellulose acetate

Cellulose acetate can be used in specialty lacquers for metals where resistance to light and heat is important. Because of its higher cost and limited solubility, cellulose acetate is not as popular as nitrocellulose for coatings. However cellulose acetate lacquers have a number of advantages, including low flammability, toughness, light and heat stability, and resistance to weak acids, alcohol, oil and gasoline. Alkali and moisture resistance of the lacquers is poorer than for other cellulosic coatings.

Cellulose acetate is not compatible with ethyl cellulose, acrylics, polystyrenes, chlorinated rubber and some synthetic rubbers. It has limited compatibility with acetate butyrate and acetate propionate, but good compatibility with nitrocellulose if mutual solvents and plasticizers are used.

Cellulose acetate butyrate

The solubility and compatibility of cellulose acetate butyrate polymers are somewhat better than in cellulose acetate but not as good as in nitrocellulose. Compared to nitrocellulose, cellulose acetate butyrate has about equal water resistance, and heat and light resistance, and it is slower burning.

Cellulose acetate butyrate coatings have excellent long term stability and weathering resistance, and have been used as protective coatings for specialized outdoor use. Broad scale application of the coatings has been held back by their high viscosity and low solids content, but a low viscosity material has recently been developed. Clear, air drying, cellulose acetate butyrate coatings are now available with an application solids content of 13%. These coatings have excellent resistance to weathering, yellowing, humidity, salt spray and weak acids. Principal uses to date have been for aluminum truck and trailer bodies, window frames and outdoor furniture.

High-butyl acetate butyrates also make excellent hot melt strippable coatings. These clear coatings are applied in comparatively heavy thicknesses to protect metal products during shipping and storage. They are very effective in protecting parts from marring, water, grease and other damaging conditions.

Ethyl cellulose

Ethyl cellulose provides greater coverage (for an equal weight) and is more resistant to alkalis than other cellulosic coating materials. It is more sensitive to acid attack, although it is not seriously affected by dilute acids. Ethyl cellulose is tasteless and nontoxic, and is less flammable and more resistant to heat, light and electrical breakdown than nitrocellulose. Like cellulose acetate butyrate, ethyl cellulose can be used for strippable coatings.

Ethyl cellulose can be combined with a number of resins and plasticizers to improve flexibility, adhesion and moisture resistance. It is compatible with many varnish resins, vegetable and mineral oils, long-oil alkyds, some waxes, and nitrocellulose. Normally, it is not compatible with cellulose acetate, cellulose acetate butyrate, acrylics, polystyrene, and natural and synthetic rubbers. However, in some cases it can be made compatible with these materials by adding a third material which is a mutual solvent.

Coumarone-indene

based coatings provide good resistance to chemicals and water. Coumarone-indene resins are usually used with other coating resins to produce a combination of properties not obtainable in either resin alone.

High proportions of coumarone-indene resins are frequently used in varnishes to improve their dielectric properties and their resistance to brine, acids, alkalis and water. Coumarone-indene resins are thermoplastic. They tend to discolor when exposed to sunlight. When used alone they have only fair durability outdoors; however, this property can be improved by adding flake aluminum pigment or phenolic resins.

Coumarone-indene resins are compounded with phenolics as marine finishes for tanks and for filling voids. High proportions of the resins are also used in bituminous coatings to improve their quick setting properties, luster and chemical resistance. Relatively small percentages of coumarone-indene are sometimes added to alkyds to improve their gloss and setting rate. Similarly, the resins can be added to chlorinated rubber coatings to improve their adhesion, gloss and corrosion resistance. The resins are sometimes used with vinyl lacquers to improve adhesion.

Epoxy

coatings are noted for their excellent adhesion, flexibility, toughness and chemical resistance.

For best results, epoxy resins must be modified chemically or blended with catalysts, curing agents or other resins. In general, six principal types of coatings are available:

Epoxy-phenolic

The outstanding properties of epoxy-phenolic baking coatings are their toughness, flexibility, adhesion, heat resistance and electrical properties. They also have the best chemical and solvent resistance obtainable with epoxy resins.

Most phenolic resins have poor initial color and color retention. Thus, epoxy-phenolic coatings can only be used where the color of the coating is not important; e.g. wire coatings and impregnating varnishes, and coatings for cans, drums and tanks.

Epoxy-urea

The physical and chemical properties of epoxy-urea coatings approach those of the epoxy-phenolics. However, the epoxy-urea coatings have the advantage of good initial color and color retention in clear and white finishes, and are more suitable for decorative uses. Typical applications: appliance primers, can linings, hospital and laboratory furniture, and clear coatings for brass hardware, costume jewelry and vacuum metallized plastics.

Epoxy-amine

Epoxy-amine coatings are usually cured by air drying. Their chemical resistance is not as good as that of epoxy-phenolics and epoxy-ureas. Nevertheless, they have excellent chemical and solvent resistance compared to other air dried coatings.

Epoxy-amine coatings are most widely used in industrial maintenance applications and for certain original equipment where baking is inconvenient or not feasible. Typical applications: linings for transmission pipelines, and coatings for machinery, process equipment, and structural steel in chemical plants.

Epoxy-polyamide

Epoxy-polyamide coatings contain polyamide resins that have amino reactive groups. Thus, these coatings and the epoxy-amine coatings are closely parallel in handling properties, curing requirements, film properties and applications. In general, the epoxy-polyamide coatings have somewhat poorer solvent resistance and initial color than the epoxy-amine coatings, but they have slightly better flexibility on aging.

Unmodified epoxy resin ester

These coatings have excellent mechanical properties and are lower in cost than most other epoxy coatings. Epoxy resin esters closely parallel alkyd resins in vehicle properties and curing requirements. They are usually cured by baking but can be cured at room temperature if driers are added. They generally have better flexibility, adhesion, toughness and chemical resistance than the alkyds, but are slightly more expensive and do not have quite as good color retention.

Unmodified epoxy resin ester coatings are widely used as overprint varnishes; as primers for automobiles, appliances and other equipment; and as original and maintenance coatings for structural steel.

Modified epoxy resin ester

These baking coatings are based on solution blends of drying-type esters with melamine or urea resins. They provide better hardness and chemical resistance than the unmodified ester coatings, but have poorer flexibility and impact resistance. Slightly better initial color and color retention can be obtained when esters made from non-drying acids are used.

Fluorocarbon

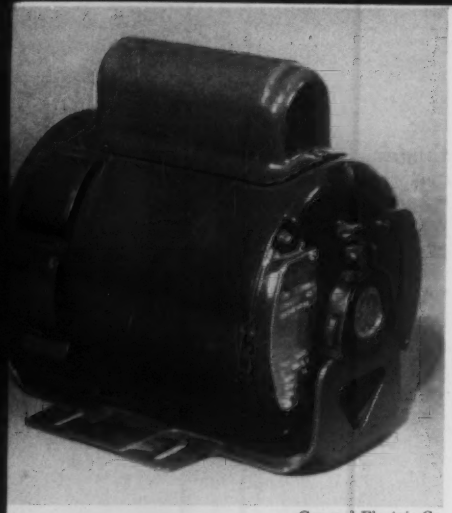
coatings are characterized by their high chemical resistance, good dielectric properties, low coefficient of friction, and high resistance to wear and abrasion.

Fluorocarbon coatings are comparatively new and are proving quite popular because of their unique combination of chemical, mechanical and electrical properties. Air drying as well as baking types are available.

Air drying fluorocarbon coatings consist of low molecular weight CFE (polychlorotrifluoroethylene) resins or resin mixtures containing TFE (polytetrafluoroethylene) resin. The coatings are applied from solvent solutions, the film forming by solvent evaporation.

Baking type fluorocarbon coatings are dispersions of finely divided TFE resins (such as Teflon) or CFE resins (such as Kel-F, Polyfluoron and Fluorothene) in aqueous or spirit vehicles. In some cases, the TFE resins are combined with other resins such as phenolics if special properties are needed.

Chemical and corrosion resistance —In general, TFE coatings provide high chemical resistance. Because of their mechanical structure the coatings usually show poor resistance to hot (200 F) nitric and hydrochloric acids, particularly in the vapor phases, and to some corrosive chemical solutions. However, they provide good protection against 20% hydrochloric and nitric acids at room temperature, 73% caustic soda, 95% sulfuric acid, and toluol at 200 F. The coatings are also resistant to such diverse chemicals as: phenothiazine, diphenylamine, hydrogen sulfide, ammonium sulfate, sulfur vapor, diethylene glycol, sulfonated oils, sulfated higher alcohols, ter-



General Electric Co.

Industrial electric motor *is protected against water, solvents and oils by a phenolic primer.*

National Polymer Products, Inc.

Loading hook *and similar parts that come in sliding contact with other metals can be given a nylon polyamide coating to lower friction and prevent galling and scatching.*

Shipboard motor *and other marine components are protected against atmospheric salt water corrosion by neoprene coating.*

E. I. du Pont de Nemours & Co., Inc.

penes, and aromatic and aliphatic hydrocarbons.

High-molecular-weight CFE coatings are less permeable to liquids and gases than TFE coatings. CFE coatings are unaffected by solvents, ozone, sunlight, and strong bases and acids, including fuming oxidizing acids. Some unsaturated and halogenated hydrocarbons, as well as ethyl ether, anhydrous chlorine and molten alkali metals, affect CFE coatings in varying degrees.

Some typical examples of where fluorocarbon coatings are now being used in corrosion resistance applications are: centrifugal pumps, paint mixers and drums, metal spray shields, pipelines, valves, flowmeters, shipping containers, trailer and storage tanks, and fume exhaust blowers.

Frictional and wear properties—The excellent frictional and wear properties of fluorocarbon coatings are well known. TFE, in particular, has an extremely low coefficient of friction and can be considered self-lubricating. TFE surfaces also have very good anti-stick properties and are not adhered to by such materials as textile size, glues, inks, paints, greases, meats, baked goods, candies and waxes. CFE surfaces have similar anti-stick properties except against the most tacky substances and at high service temperatures.

Some applications where fluorocarbon coatings are valuable in providing low friction and high abrasion resistance are: bearings, conveyor chutes, extrusion dies, feeder troughs and hoppers, snowplow blades and molding dies. The anti-stick properties of the coatings are particularly valuable in food, bakery and candy processing.

Thermal properties — TFE coatings can be used continuously at 480 to 550 F and intermittently at higher temperatures. In comparison, CFE coatings can be used continuously at 390 F and intermittently at 420 F. All of the coatings are non-inflammable and are not affected by open flame. They also have excellent flexibility at low temperatures.

Normally, TFE baking coatings are fused at 650 to 750 F, and CFE coatings at 475 to 515 F. However, a new series of TFE coatings (Emralon) has recently been developed that can be cured at 300 F and lower, making these coatings suitable for wood, rubber, plastics and temperature-sensitive metals.

Electrical properties—TFE coatings have outstanding dielectric properties over a wide range of frequencies and temperatures. This is true to a lesser degree for CFE coatings. The low water absorption and non-wetting properties of fluorocarbon coatings tend to improve their insulating qualities by reducing surface arcing and corona losses.

How they are applied — Fluorocarbon coatings are usually applied by conventional brush, dip, or spray methods. However, two application methods recently developed may extend the utility of the materials.

FEP (fluorinated ethylene propylene) coatings have been successfully applied by the fluidized bed method. After preparing the surface, the base metal is preheated and then placed in the fluidized bed where it is coated with FEP powder resin. The metal is then removed and the resin fused at 662 F. Repetition of this procedure can produce a coating up to 20 mils thick. The adhesion of this coating is said to be far superior to that of coatings applied by conventional methods.

Electrodeposition has also been used to produce heavy, nonporous TFE coatings from a resin dispersion (Teflon 41-BX). The dispersion contains 33 to 35% TFE in the form of hydrophobic, negatively charged particles. Parts are coated by passing direct current through the dispersion, causing the negatively charged particles to migrate toward and deposit on the substrate which is the positive electrode.

Phenolic

coatings exhibit excellent resistance to chemicals, solvents, oil and water, and have high abrasion and mar resistance.

Phenolic coatings can be divided into four main types: straight (100%) phenolics, substituted or polyhydroxy phenolics, blocked phenolics, and phenolic oil varnishes. When fully cured, most phenolic resins tend to be brittle. With some exceptions (notably the phenolic oil varnishes), phenolic resins must be plasticized or modified with another resin where very good flexibility is needed. Epoxy, polyvinyl butyral and polyvinyl formal resins are widely used for this purpose.

An exceptionally good combina-

tion of properties can be obtained by using phenolic-epoxy blends. These blends combine the best properties of each resin and may be used clear, as high gloss pigmented topcoats, and as pigmented primers. Increased epoxy content tends to increase flexibility and reduce resistance to strong solvents.

Phenolic coatings are usually used as clear coatings or as primers. Both types are usually baked and have similar properties and applications. Some catalyzed resin solutions will cure at room temperature; however, these coatings usually lack the chemical resistance of baked coatings.

Clear coatings

Because of their highly cross-linked structure, phenolic resins produce dense, impermeable coatings on metal surfaces. Moisture permeability is extremely low and corrosive ions from chemicals penetrate very slowly.

Clear phenolic coatings are generally unaffected by most solvents, and have high resistance to mineral and organic acids as well as aqueous solutions. However, only the blocked phenolics have really good resistance to alkalis, soap solutions, and oxidizing media such as chromic acid. Although phenolic coatings have high resistance to mineral acids, only a few of them can be used with hydrochloric or nitric acids in concentrations over 20%. This is especially true at high temperatures. The coatings can generally be used with all concentrations of phosphoric acid and up to 50% sulfuric acid.

The abrasion resistance of clear phenolic coatings ranges from good to excellent. With the exception of phenolic oil varnishes, phenolic coatings are not inherently flexible and, when unmodified, have poor resistance to impact and flexure. However, a number of resins can be plasticized in relatively thin films (0.1 to 0.3 mil) to withstand the severe drawing and forming encountered in can manufacture. Good adhesion is obtained on most metals.

Clear phenolic coatings can withstand dry heat up to about 700 F for short periods. However, extended exposure tends to make the coatings darken and become brittle. Other than reducing flexibility, low temperatures have little effect on the coatings.

Primers

Despite their greater porosity, highly pigmented phenolic primers provide just as good protection as clear coatings against aqueous solutions and high humidity. However, resistance of the primers to corrosive chemicals is lower. If resistance to strong alkalis or acids is needed, pigments must be used that are resistant to these media.

All of the phenolic coating resins tend to yellow when baked. Exact duplication of shades cannot be expected, as variations in bake time or temperature tend to produce different shades of yellowing. Phenolic resins are not suited for white or very light tints.

Pigmented phenolic primers are used extensively in multiple coats as linings for storage tanks and tank cars and processing equipment. They have also been used for many years on appliances under alkyd-amine topcoats.

The Importance of Pigments

In addition to providing color, pigments play an exceptionally important role in determining the protective properties of organic coatings. In many cases, the choice of pigments is even more important than the choice of the resin used, as in the case of some corrosion resistant primers and zinc-rich paints.

No single pigment can serve all purposes and for this reason paints are usually provided with several pigments to provide a wider range of properties. Reactive pigments can be used for priming protection or to harden and strengthen the coating. Nonreactive pigments can be used for color and to eliminate stresses and promote elasticity. Other pigments may be used to exclude ultraviolet light or to decrease moisture permeability.

Polyamide

coatings decrease wear, particularly under abrasive conditions where lubrication is difficult. They also protect metals from weathering and chemical corrosion, and improve product appearance.

Several types of polyamide coatings are available for protecting metal surfaces. Each of these coatings is designed to be used under a specific set of operating conditions and no one type can provide all of the properties outlined above.

Nylon

The excellent wear and frictional properties of molded nylon parts are widely recognized. In general, these same properties can be obtained in the form of nylon coatings.

Nylon coatings can be applied in several ways, including flame spraying and the promising fluidized bed process. Comparatively heavy coatings are preferred for most uses. However, thin coatings of about 2 or 3 mils have proved to have better wear resistance in some bearing applications, presumably because of their better heat dissipation.

Some typical metal products whose frictional properties have been improved by nylon coatings are: bearings, chuck pins, sheaves, textile guide arms, hoppers, plunger parts, cams and rollers.

Thermosetting blends

Thermosetting resin blends or alloys are made of a type of polyamide resin that contains free amino groups. Combination of this resin with epoxy or phenolic resins produces coatings with high chemical and corrosion resistance.

Polyamide-epoxy coatings—When pigmented, these coatings have high gloss, hardness and flexibility combined with resistance to solvents and chemicals. The coatings have excellent resistance to the passage of moisture and consequently are quite durable. They have little tendency to check or crack and have excellent color retention and adhesion. Polyamide-epoxy coatings are widely used on dairy equipment, pipelines, oil well riggings, freight car interiors, water softeners and laboratory equipment, and as maintenance finishes.

Polyamide-phenolic coatings — These coatings have the high chemical and solvent resistance of phenolic resins combined with the flexibility, impact resistance and alkali resistance of polyamide resins. Because of their excellent storage properties, the coatings may be used in applications for which the straight polyamide and polyamide-epoxy coatings are not suitable. However, the polyamide-phenolic coatings require baking at temperatures of at least 300 F, whereas

polyamide-epoxy coatings can be cured at as low as 50 F.

Because of their chemical and corrosion resistance, polyamide-phenolic coatings are used to line drums, tanks, cans and pails. They are not pigmented as frequently as polyamide-epoxy coatings; pigments are used primarily for corrosion protection rather than decoration.

Rilsan

Rilsan (the tradename for polyamide-11) coatings can be flame sprayed on most metals and on paper. They have a low coefficient of friction and excellent adhesion, and are very resistant to shock and vibration. They also have low moisture pickup (less than 1%) and high thermal conductivity. Useful temperature ranges from —75 to 285 F.

Since the coatings are tasteless and nontoxic they are useful for lining food containers. The coatings are particularly valuable in protecting electrical parts (such as switch boxes and casings) that are exposed to corrosion in mines, ships, and tropical atmospheres.

Vegetable oil polyamides

Vegetable oil polyamide resins are soluble in alcohols and alcohol-hydrocarbon mixtures. They can be used alone or with modifiers as surface coatings on a variety of metallic as well as nonmetallic surfaces. The coatings are particularly noted for their heat seal properties and their resistance to grease and water.

Rubber

coatings can be formulated with a wide range of properties, such as high resistance to chemicals, water, weathering and aging. Some types are extremely tough, are usable over a wide temperature range, and are noninflammable.

The outstanding feature of coatings based on rubber materials is their high resistance to chemicals and corrosion. By suitable compounding and blending a number of other valuable properties can be obtained. Following are the most important types:

Neoprene

Neoprene (chloroprene) coatings are available as standard or heavy-coat liquid coatings, trowel cements or putties, ready-mixed coatings, and neoprene latex. The liquid solution coatings are applied just like any other paint, and when the solvent evaporates a tough, impermeable coating is formed.

The outstanding property of neoprene coatings is their chemical resistance. They are resistant to alkalis, natural oils, aliphatic hydrocarbons, most salts, alcohols, and many organic and inorganic acids. The coatings are permeable to, but not attacked by, concentrated halogen acids such as hydrochloric and hydrofluoric. However, they are attacked by oxidizing agents such as concentrated sulfuric acid, nitric acid, chromic acid, sodium and calcium hypochlorite, chlorine gas and hydrogen peroxide.

Neoprene coatings have unusually good weatherability and aging properties. With the exception of Hypalon, neoprene has better weatherability than other rubber coatings.

Neoprene coatings retain their flexibility and are undamaged at low temperatures. In general, they tend to harden upon prolonged exposure at temperatures over 200 F; however, they will not support combustion. Like other rubber coatings, they also have excellent resistance to abrasion and general wear and tear.

Some typical applications: 1) ductwork exposed to corrosives, 2) pipelines subject to corrosion and erosion, 3) exhaust blowers subject to corrosive acids, 4) pump blades subject to cavitation, 5) chutes carrying abrasives, 6) tank cars carrying caustic soda, and 7) aircraft surfaces subject to rain erosion.

Hypalon

The most outstanding property of Hypalon (chlorosulfonated polyethylene) synthetic rubber coatings is their resistance to ozone and other oxidizing influences. Thus, Hypalon coatings are superior to all other elastomeric coatings in resistance to weathering. In addition, they can be obtained in an almost unlimited range of fadeproof colors.

Hypalon also has very good resistance to chemicals, particularly strong oxidizers. There are some exceptions — notably carbon tetrachloride, formaldehyde, gasoline, jet engine fuel, xylene, and some concentrations of nitric, hydrochloric and acetic acids.

As with chemical resistance, the low and high temperature properties of Hypalon coatings depend on the formulation used. Low temperature Hypalon compositions retain their flexibility at –30 to –40 F, and have been formulated to resist embrittlement as low as –80 F. Some coatings can be used as high as 300 F. Hypalon coatings burn in the presence of flame, but are self-extinguishing when the flame is removed. If corrosion protection is required at very high temperatures it may be advisable to use a coating material such as Viton fluoroelastomer. Viton elastomeric coatings are comparatively new and, in addition to having the same general resistance properties as Hypalon, they can be used at temperatures up to 600 F in intermittent service.

Hypalon coatings can be formulated so that they either restrict or conduct the flow of electricity. Dielectric-type coatings retain their dielectric properties up to 255 F, and are well suited as high temperature electrical insulations. Conductive-type coatings offer an easy path for the flow of electricity. Hypalon-coated steel can be welded electrically to other metal without having to remove the coating under the electrode.

Specially formulated Hypalon coatings can be used as linings for tanks, ducts and similar equipment. Coatings have been successfully used on acid pumps and butterfly valves in contact with acids, and on copper racks used in highly corrosive plating solutions.

Chlorinated rubber

Like many other coating materials, chlorinated rubber cannot be used in its unmodified state. Some of the materials with which chlorinated rubber has been modified are alkyds, phenolics, maleic resins, coumarene-indene resins and chlorinated diphenyl. Following are some properties that can be obtained with special coating formulations. Keep in mind that these properties are not necessarily characteristic of all chlorinated rubber coatings.

Chemical resistance—Chlorinated rubber coatings formulated for maximum protection against chemicals are resistant to most common inorganic acids at room temperature. Coatings are effective barriers to dilute acids up to 140 F even under continuous exposure. Performance of the coatings with concentrated mineral acids depends on temperature and type of service. The coatings have good resistance

to all the common alkalis, excepting ammonium hydroxide. They are also resistant to many oxidizing agents, salt solutions, moist gases, halogens, and mineral and vegetable oils.

Some typical examples of where chemical-resistant chlorinated rubber coatings are used: stop-off coatings for electroplating, alkali resistant appliance enamels, tank car coatings, and maintenance coatings in chemical plants, gas works and petroleum plants.

Water resistance—The excellent resistance of chlorinated rubber coatings to salt spray and fresh and salt water immersion is particularly valuable in marine applications. Chlorinated rubber coatings are recommended for the decks and hulls of yachts, barges and other craft. The coatings form hard, smooth surfaces which deter the adherence of marine growths.

Thermal properties — Chlorinated rubber is widely used in noninflammable and fire-retardant coatings. These coatings are used by the U.S. Navy for ship interiors where, in addition to noninflammability, they must also be durable under conditions unfavorable to long paint life. Similar noninflammable coatings are also used as machinery enamels and for various metal products.

Cyclorubber condensates

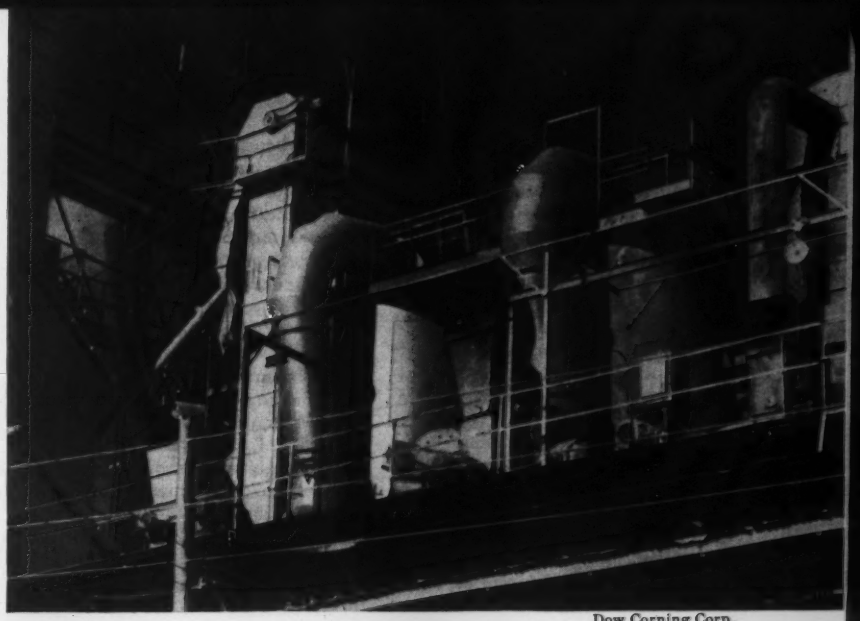
Coatings containing cyclorubber condensates have high chemical resistance, especially to alkalis. For this reason they are especially useful as concrete floor paints and as coatings for caustic soda tanks and tank cars. A typical tank coating consists of the cyclorubber condensate mixed with carbon black, China-wood oil and mineral spirits. About three coats are required to protect tanks against 50 to 70% concentrations of caustic soda.

Other applications for cyclorubber condensates: laboratory paints, red-lead primers, weather resistant aluminum paints, marine paints, and general maintenance coatings to resist acids, fumes and corrosion.

Silicone

coatings have excellent resistance to heat, moisture, salt spray, acids and alkalis. When modified they are also flexible and abrasion resistant.

The chief advantage of silicone coatings is their heat resistance.



Dow Corning Corp.

Outdoor processing equipment *is frequently coated with silicone paints with high content of aluminum pigments to protect against effects of high operating temperatures and industrial atmospheres.*

Commercial white enamels are unaffected by temperatures as high as 750 F—almost midway between the upper limits of conventional paints and inorganic coatings like porcelain. In addition, silicone coatings provide excellent resistance to oxidation and weathering, and have good color and gloss retention. They also have high water repellency and moisture resistance, and are good electrical insulators. Fully cured coatings have high resistance to salt spray, acids and alkalis. However, their resistance to these media below 350 F is not as good as that of epoxy or vinyl coatings.

Painted surfaces are quite easy to keep clean because of their high resistance to dirt adhesion. Since they are inert, silicones do not promote bacteria growth. However, their main advantage in combating such growths is their innate water repellency and moisture resistance.

The relative inertness of silicone resins tends to reduce the adhesion of coatings. Silicone coatings also tend to be soft, despite any increases in baking times.

A large number of silicone coating formulations are available for specific end uses. These coatings can be roughly divided into the following types:

Baking enamels

Baking enamels are generally broken down by their silicone content—high, medium or low. Cost of the enamels varies directly with silicone content. Unmodified enamels containing 100% silicones have a maximum operating temperature of 500 F and are used on incinerators and for touching up porcelain enamel.

Modified coatings with a silicone content of 65 to 85% are good from 450 to 500 F and are used in such applications as space heating casings and furnace exteriors. Modified coatings containing 10 to 70% silicones are good up to 450 F and are used for exhaust manifolds, space heater combustion chambers, and heating appliance trim and name plates. Some of the materials that are used to modify the basic silicone resins are alkyds, phenolics, coumarones, ester gums, epoxies, acrylics and cellulose derivatives. Color retention in the modified coatings is usually a problem, and the coating formulator should be consulted if decorative requirements are severe.

Metallic-pigmented coatings

Several metallic-pigmented coatings have been developed for use at temperatures as high as 1200 to 1500 F. These coatings consist of silicone vehicles heavily loaded with metallic pigments such as powdered aluminum or zinc dust. The main advantage of the silicone vehicle is that it provides corrosion protection at much higher temperatures than organic resins. After prolonged heating at 700 to 1000 F the silicone gradually volatilizes, but its matrix still holds the metal pigment firmly

in place. The decorative appeal of silicone-aluminum formulations can be increased by using certain colored pigments to produce ranges of "satin" or "metalescent" shades.

Metallic-pigmented silicone coatings are used in many high temperature applications such as space heater combustion chambers, incinerator interiors, mufflers and exhaust systems, electrical equipment, heat exchangers, high pressure steam lines, furnace casings, arc light reflectors and gas range shields.

Specialty coatings

The prestige value of silicones has been used in so-called "siliconized" coatings. These formulations usually contain less than 1% silicone fluid which is no more than an additive. Though billed as silicone coatings, some of these special formulations might better be described as very superior alkyd-amines. Their primary advantages, none of which are normally associated with silicones, are superior hardness and flexibility, and resistance to abrasion, chipping and staining. None of the white enamels in this group are recommended for use over 250 F. Darker colors can be used up to 500 F without discoloration.

These specialty coatings are chiefly recommended for consumer products such as refrigerators, ranges and washers. When used in industrial applications they are claimed to provide protection equal to galvanizing at less cost and with better appearance.

Styrene-butadiene

primer coatings are easy to apply and can be formulated to provide excellent rust inhibiting and chemical resistance properties plus good adhesion.

Styrene and butadiene are copolymerized to form coating materials with a good combination of properties. The proportion of styrene to butadiene determines the properties of the coatings, which can range all the way from a weak, friable coating to a soft, rubber-like coating.

Styrene-butadiene coatings for metal products are usually used in the form of solvent-base primers or water-thinned latex primers. In general, the solvent-base primers have superior resistance properties; however, the water-thinned latex primers have the advantage of being noninflammable and safer to use.

Solvent-base primers

Styrene-butadiene metal primers provide protection against a number of chemicals such as acids, alkalis, greases, alcohol, food products, soaps and detergents, as well as water and high humidity. The low moisture permeability and good film strength of the primers combine to prevent undercoat rusting, and also provide an excellent base for subsequent topcoats. The primers are easy to apply and dry quickly (dust-free in about 1 to 3 hr). Good and lasting adhesion is obtained on many base metals. As with most primers, the properties of styrene-butadiene primers depend to a large extent on the pigments used.

Water-thinned primers

Of the three major water-thinned paints for metals—styrene-butadiene latices, vinyls, and acrylics—styrene-butadiene has been the most successful to date. Several automotive and appliance baking primers have been developed and are now under test. The automotive primers are noted for their good spraying characteristics, good adhesion and sanding properties, and resistance to humidity and salt spray.

Both gloss and semi-gloss baking enamels can be made with styrene-butadiene latex, but as yet properties of these coatings are not as good as those of solvent-type baking enamels. They generally require a high binder-to-pigment ratio to produce a high gloss and do not have sufficient color retention at high temperatures to permit formulation of white or light colored coatings.

Urethane

coatings are resistant to moisture, chemical corrosion and weathering. They are also exceptionally tough, flexible and resistant to abrasion.

Urethane (or polyurethane) coatings are comparatively new and are produced by the reaction of polyisocyanates with one or a combination of selected resins. Properties of the coatings depend largely upon the type of resin used and upon the proportion of isocyanate.

Chemical resistant coatings

The most corrosion resistant air dry coatings available are based on TDI(tolylene diisocyanate)-adduct-polyester resin urethane systems. These coatings are supplied as clear or pigmented two-package systems

Mobay Chemical Co.

***Aluminum pipe interiors** have polyurethane coating to provide smooth surface and resistance to salt water, acids, caustic fluids, crude oil and other corrosive agents.*

and can be used on any surface that must be protected from water, solvents, chemicals or weathering. They also have high hardness and good impact properties which make them highly resistant to wear, chipping and mechanical abuse. Because of these properties, urethane coatings are especially useful for protecting fuel tanks and barges, water storage tanks, pipelines, oil well drilling rigs, laboratory furniture, machinery, ventilation equipment, and electrical equipment.

At present, urethane coatings cannot be used where a high degree of whiteness retention is required. When exposed to ultraviolet light, urethanes have a tendency to lose their gloss and to yellow in the white and pastel shades. However, these deficiencies are no worse than in comparable corrosion resistant coatings and are considerably less than in oil-type varnishes.

Baked coatings

The most common type of urethane coatings in use today is based on blocked isocyanate adducts (or addition products) which, when heated in the presence of a resin, form extremely tough and durable coatings. The most noteworthy application of these coatings is magnet wire or other uncovered electrical wire. In addition to high durability, they also have good dielectric properties and are unique in that they are self-fluxing, i.e., they do not need to be removed prior to soldering. Baked urethane coatings are also being successfully applied to oil well drilling pipe, where their high resistance to chemicals, oils and shock has proved extremely valuable.

Vinyl

coatings are tough and flexible, have good adhesion, and are resistant to aging, weathering and many chemicals.

Vinyl coatings are quite versatile and can be used to protect metal products under a variety of operating conditions. Since the resins are odorless and tasteless and have low toxicity, they are quite useful as sanitary coatings. Properly pigmented coatings have high resistance to outdoor exposure. Because of their good toughness, flexibility and adhesion, vinyl coatings can be applied to many metal parts before they are fabricated.

Vinyl resins containing vinyl chloride are very resistant to chemicals. Coatings are not attacked at room temperature by inorganic acids or alkalis. They are also resistant to fresh and salt water.

In general, vinyl coatings can be divided into the following broad categories:

Wash primers

Wash primers based on vinyl butyral resins provide excellent anticorrosive properties and a good adhesive bond for subsequent topcoats. Specialty formulated primers have excellent adhesion to steel, iron, chromium, cadmium, aluminum and magnesium surfaces. Phenolic, nitrocellulose, as well as other vinyl coatings, have excellent adhesion to these vinyl butyral wash primers.

Wash primers dry entirely by solvent evaporation. The coatings are tough and flexible over a wide temperature range. Formulations with high pigment content show no undue loss of mechanical properties and have high durability and color stability outdoors. They are widely used for maintenance of marine equipment and have also proved effective in protecting original equipment. Aluminum aircraft surfaces, galvanized iron, and signs are often coated with a vinyl wash primer to improve topcoat adhesion.

Solution coatings

Vinyl copolymer solution coatings are neutral and non-oxidizing, and have a low order of odor and taste (they have been used in food packaging for over 20 years). They are not attacked at room temperatures by alkalis, mineral acids, alcohols, greases, oils or aliphatic hydrocarbons. Toughness and abrasion resistance are high, especially in coatings utilizing the higher molecular weight resins. The coatings have good flexibility down to 65 F, but cannot be used over 160 F. They can be cured by air drying or baking.

Vinyl solution coatings are comparatively costly, but their special properties make them economically feasible in a number of applications. A leading application has been the interior coating of beer and soft drink cans. Baking a solution coating over a phenolic or epoxy primer produces a tough flexible coating system which completely protects the liquid from contamination.

Diverse items such as metal cabinets, toothpaste tubes, bottle caps, time clocks, and wash stands and showers are protected from abrasion and corrosion with vinyl solution coatings. The coatings are also used on milking machines, separators, and other dairy equipment exposed to severe cleaning solutions, lactic acid and abrasion. Air drying coatings are frequently used on radar and other electronic equipment to prevent damage to delicate parts that might occur in baking. Solution coatings are also regularly used as topcoats over wash primers to protect products against salt or fresh water.

Vinyl solution coatings are also widely used for strippable coatings to protect metal products against marring and deterioration encountered during storage. A wide variety of compositions are available and, depending on the application, they can be adjusted to provide varying degrees of elasticity, tensile strength and adhesion.

Dispersion coatings

Vinyl dispersions are finely divided suspensions of resin particles in organic media. Their main advantage over solution coatings is their higher solids content. Vinyl dispersions are divided into two groups: plastisols and organosols. A plastisol is a nonvolatile suspension of resin particles in a plasticizer with stabilizers and pigments added. An organosol is similar except that it contains a volatile diluent or a mixture of dispersant and diluent.

Both plastisols and organosols are noted for their toughness, resiliency, nonporous structure, and resistance to abrasion and oxidation. Their thermal and chemical properties are roughly the same as those of vinyl solution coatings. However, they should not be exposed to ketones, esters, or chlorinated or aromatic hydrocarbons. Organosol coatings are comparatively hard. Plastisols, in contrast, form softer and glossier rubber-like coatings. Cured coatings as thick as ¼ in. can be obtained in one application. The thickness of plastisol coatings provides high protection to metal surfaces; however, plastisols have poorer properties than organosols on a mil-for-mil basis. Both coatings must be cured by baking and they must usually be applied over a primer or an adhesive to obtain good adhesion.

Textured organosol coatings have been spray-applied to auto instrument panels and the back panels of station wagon seats. Coatings have a leather grain appearance and high abrasion resistance, and are said to be less costly than corresponding alkyd coatings.

The wide uses for plastisol coatings are well known. Textured plastisols can be used on such products as radio cabinets, air conditioners, file cabinets, and auto dashboards and kick plates. Some uses for plain plastisols are office equipment, lawn furniture, refrigerator shelving, and interiors of vending, dishwashing and laundry machines.

Water-thinned paints

Considerable progress has been made in developing water-thinned polyvinyl acetate paints for metal products. These paints, which are noninflammable during application, are being used on a very small scale. However, several metal primers and gloss paints have been developed and are being evaluated for large-scale industrial finishing applications.

Polyvinyl acetate metal primers are thermoplastic and soften when heated. However, where heat is not a factor, the primers show much promise because of their low cost, good air drying and baking properties, excellent color retention, and high resistance to solvents, alkalis and acids.

Other organic coatings

All of the above coating systems are in wide use today. However, there are a number of coating systems which, although not too widely used, deserve mention. Two of these systems—oil paints and 100% natural resin coatings—have gradually

been superseded by synthetic resin coatings. Polyethylenes, furanes and butyl titanates, on the other hand, have not yet achieved much prominence, mainly because of their newness.

Oil paints

An oil paint does not contain any resins and is primarily made up of a dispersion of pigments in a mixture of drying oils and a thinner. Since the thinner evaporates after application, properties of the coating derive mainly from the type of drying oil used. Comparatively flexible coatings are formed by linseed and soybean oils which dry slowly. Harder coatings are formed by tung and castor oils which dry more quickly. Other less widely used oils include perilla, oiticica, tall, fish, and synthetic-modified oils.

Oil paints are generally softer, more flexible, and less glossy and resistant to chemicals than synthetic resin-base coatings. For this reason they are not very popular today, although they are still used to some extent on large fixed structures such as bridges, oil storage tanks and water towers.

Natural resin coatings

The term natural resin describes those materials obtained from natural vegetation and includes such materials as Kauri and Congo copals, Manila and East India resins, batu and dammar resins, rosin and shellac. In the past, the resin content of all organic coatings was largely composed of these materials. However, their use decreased sharply with the development of superior synthetic resins. Natural resins are rarely used today for the main resin constituent of organic coatings for metals. However, they do have some desirable properties which recommend their use with synthetic resins to produce an improved combination of properties (as in the case of metal varnishes).

Polyethylene

Polyethylene is very desirable as a coating material because of its excellent toughness and colorability, and its resistance to water and chemicals, particularly strong oxidizing acids such as concentrated nitric and hydrofluoric acids. Thin films and linings of polyethylene can be laminated to a variety of materials, but polyethylene coatings cannot be applied by conventional brushing or spraying methods. However, in powder form the material can be applied with a flame gun or by a fluidized bed method. The coatings are claimed to have the same corrosion resistance properties as sheet polyethylene.

The fluidized bed method (insertion of a hot part into an agitated powder of the coating material) has been used to produce pinhole-free coatings from 10 to 60 mils thick on metal products. The coatings have very low water absorption and excellent corrosion resistance and dielectric properties.

Chlorinated polyether

Like polyethylene coatings, chlorinated polyether coatings can now be applied by the fluidized bed method. These coatings have a combination of high resistance to chemicals and abrasion, and can withstand temperatures from –40 to 250 F. Because of these properties, the coatings are particularly recommended for protecting metal surfaces in chemical and food processing equipment.

Furane

Furane coatings are especially noted for their outstanding resistance to acids, alkalis and other chemicals. They have been successfully used for many years to protect chemical processing equipment. However, extended application of the coatings has been held back by their comparatively high cost and poor appearance. Even though the raw materials are light in color they cure to a dark black. Thus, they are limited to industrial applications or to rare decorative applications where a dark and glossy black color can be used.

Butyl titanate

A comparatively new and significant application of butyl titanate (a titanium ester) is its use as a vehicle in heat and corrosion resistant paints. The superior properties of the coatings derive from an entirely inorganic film (strictly speaking they are not organic coatings) formed by hydrolysis of the ester which cements the particles together.

Aluminum-pigmented butyl titanate paints have proved serviceable up to 1100 F. In addition, zinc-pigmented butyl titanate paints have provided freedom from corrosion and marine fouling in salt water for periods up to two years. Some typical uses for the coatings are smokestacks, kilns, breechings, fire doors, and other applications where corrodible metal parts are exposed to high temperatures.

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Sherwin-Williams Co.
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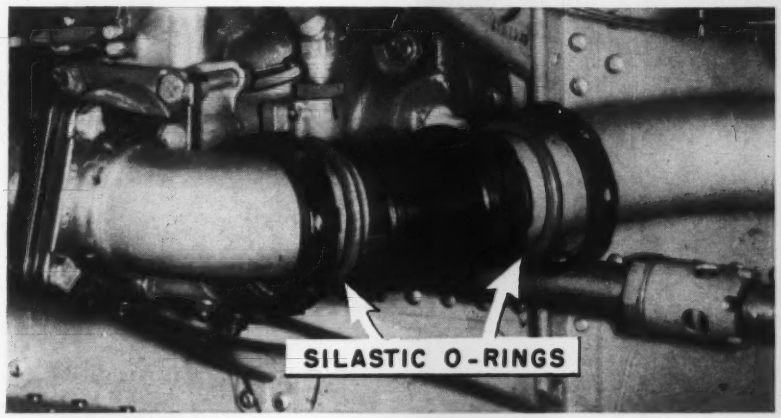


PREVENT FUEL LINE LEAKS

Jets will soon dominate commercial airways as more and more DC-8 Jetliners go into world airline service. Helping Douglas Aircraft write new commercial aviation history is Silastic® LS-53, the Dow Corning fluorocarbon silicone rubber.

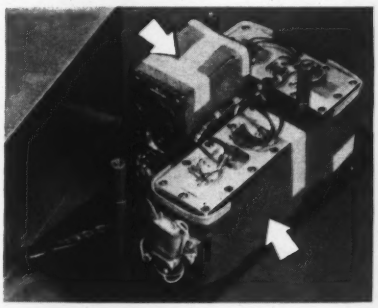
A DC-8 carries over 21,000 gallons of fuel. The hundreds of fuel line joints, connected by flexible couplings manufactured by On-Mark Engineering, Los Angeles, utilize approximately 1000 O-rings, ranging in size from 1" to 4" I. D. Keeping these flexible joints leakproof against jet fuels requires O-ring seals that meet the most rigid requirements for serviceability and reliability.

Douglas tested dozens of standard rubbery materials for fuel resistance, thermal stability, weathering, compression set and shrinkage. The tests were performed after the O-rings had been immersed in fuel for a designated period, removed, and allowed to dry out. The result was that only a special compound based on Silastic LS-53 met all service requirements. This material withstood 1,000,000 cycles of flexing without springing a leak.

Uniquely resistant to a wide variety of fuels, oils, solvents and chemicals, Silastic LS-53 is called for on an ever-growing number of specifications for sealing applications in the aircraft, automotive, electrical and petroleum industries. *No. 614*

TYPICAL PROPERTIES OF SILASTIC LS-53

Serviceable Temperature Range	**—80 to 500 F**
Compression Set, %	
22 hr at 300 F	**22**
Solvent Resistance, % swelled	
ASTM No. 3 Oil, 21 days at 300 F	**3**
Jet Fuel JP4, 15 days at 250 F	**18**



WRAP-AROUND HEATERS

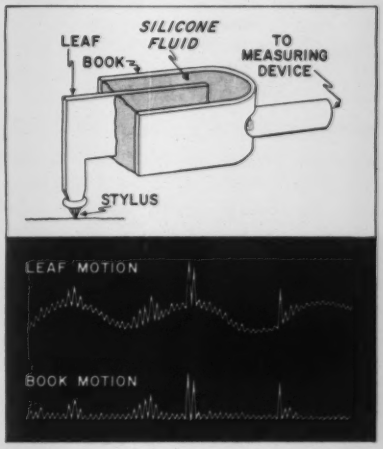
To develop a new, flexible strip heater that would be easy to install, engineers at Electro-Flex Heat, Hartford, Conn., capitalized on the electrical and physical properties of Silastic®, the Dow Corning silicone rubber.

This heater was especially designed to assure maximum operating efficiency of triaxial accelerometers built by the Avion Division of ACF Industries. The heater maintains the temperature of the accelerometer at 85 C despite exterior temperatures as low as —60 C. Simply constructed, the heater is a spread-out coil of resistance wire permanently sandwiched between layers of Silastic. Only 0.04" thick and very flexible, the units readily pinpoint controlled heat to any desired location.

Avion simply tapes a heating unit around each accelerometer. Once installed, the two thermostatically controlled heaters — one rated at 8 watts, the other at 2 watts per square inch — maintain internal temperatures at the desired level. The larger circuit helps warm up the unit and then cuts out, leaving the 2-watt circuit to maintain the temperature at 85 C, plus or minus five degrees.

Electro-Flex specified Silastic for the insulation material because of its superior physical and dielectric properties. Vulcanized in Silastic, the heater elements are completely sealed against moisture and current leakage. The silicone rubber can repeatedly withstand temperatures as high as 260 C without loss of insulating efficiency or flexibility.

As still another measure to assure smooth uniform performance, Electro-Flex engineers specify the use of a Dow Corning silicone fluid to damp movement of the accelerometer pick-off elements. *No. 615*



FOUND: EDUCATED FLUID

You can count on silicone fluids to perform exactly the same way time and time again under extremely variable conditions! Here's how designers at Archer-Reed Company, Dearborn, Michigan, put this stability to work in their Micro-Scanner:

An ultra-sensitive instrument, the Micro-Scanner can measure surface *(Cont. Pg. 2)*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

HEAT-SINK SEALANT

"Just a smidgeon" of a silicone compound is frequently all it takes to assure a new measure of reliability for delicate electronic components. Industro Transistor Corporation provides an excellent example —

Industro pots and protects the junctions of its tiny transistors with a minute quantity of a Dow Corning silicone compound. This greaselike silicone material seals out moisture, rapidly conducts heat away, and cushions the junction against shocks.

In addition, the compound prevents metal from splattering against the transistor while the cap is being welded in place. Being inert, the silicone material does not poison or contaminate the junction. Nonmelting and nongumming, Dow Corning silicone compounds maintain the same consistency from —40 to 400 F and retain their insulating efficiency through highly adverse conditions. *No. 616*

SILICONE FLUIDS *(Continued)*

roughness in increments of five ten-millionths (0.0000005) of an inch! The scanner's most unusual feature, however, is its ability to report roughness of any surface regardless of contour, as if it were flat.

Archer-Reed achieved this kind of performance by interposing a "leaf and book" floating link between a diamond-point stylus and calibrated dial. The unit is filled with high viscosity Dow Corning 200 Fluid. Any gradual up or down "leaf" movement has no effect on the "book" and therefore, does not register. On rough surfaces that cause the leaf to move rapidly, however, the viscous silicone fluid ties the leaf to the book, and the movement is transmitted to the dial.

The amount of 200 Fluid used in the Micro-Scanner is insignificant, but the device is designed around it and wouldn't work without it. A high viscosity 200 Fluid proved ideal for this application because the silicone fluid's viscosity is virtually unaffected by temperature, oxidation or breakdown under shear. A test scanner initially charged two years ago with 200 Fluid still has the same volume of liquid, and viscosity is unchanged.

OTHER FACTS about Dow Corning silicone fluids: serviceable from —100 to 400 F, they are available in many viscosities to meet specific requirements. *No. 617*

new literature and technical data on silicones

DESIGNS ON THE MOON. Created specifically to meet the informational needs of rocket and missile designers, an illustrated 8-page brochure describes the finest in silicone materials—rigid, rubbery, fluid, and dielectric. Whether you're concerned with nose cones, guidance frames, propulsion, or ground supports, your most rapid progress toward miniaturization, weight reduction, and just plain reliable performance may depend on the specification of silicone products. Explore the possibilities that Dow Corning Silicones offer. *No. 618*

ANOTHER FIRST for Dow Corning Silicones. A compilation, reprinted from Electronic Design, is now available. This designer's reference is arranged as a materials selection guide spelling out the "why" and "how" of various solutions to each of a dozen problems confronting designers of electronic equipment. This valuable, 8-page materials selection guide can be added to your files by writing for ---------- *No. 619*

SEE SILICONES IN ACTION at the IRE show March 23 through 26. If you miss the show, you can still get close to the engineering attributes of silicones as dielectrics. A 12-page booklet reviews silicone fluids, compounds, resins, varnishes, wire enamels, laminates, and other proven materials for the design of electrical and electronic equipment. *No. 620*

WHAT silicones can best meet the needs of a variety of problems involving materials ranging from resins to rubbers, dielectrics to water repellents; graphic examples showing WHERE many Dow Corning silicone products are currently being used; and information on HOW to get specific data on the Dow Corning silicone material best suited to any application are contained in the 1959 Reference Guide. This up-to-date, 16-page selector is ready for your files. *No. 621*

LESS TOIL through utilization of solventless silicone laminating resins. These Dow Corning materials offer designers a fast and economical wet lay-up method of making intricate prototypes or short production runs where expensive dies are not justified. Outlining excellent heat resistance, electrical properties and superior water repellency, a new data sheet also describes how these two glass laminating resins can be blended to meet viscosity requirements. *No. 622*

Dow Corning Corporation, Dept. 7015, Midland, Michigan

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Impact Strength of Metals

Notched Izod, ft-lb[a]

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Austenitic Stainless Steels, Ann.	123	42	Stainless Steels (cast)	24	22
Cobalt Alloys	120	—	White Metal (cast)	22	—
Nickel-Chromium-Molybdenum Steels (86xx, 87xx), H & T (1200 F)	87	18	Carbon Steels (cast), Norm & T	20	—
Nickel Steels, H & T	75	20	Ferritic Stainless Steels, Ann.	14	11
Nickel-Chromium-Molybdenum Steels (43xx), H & T (1200 F)	74	1	High Carbon Steels, Ann.	14	8
Martensitic Stainless Steels, Ann.	70	20	Tin (cast)	14	—
Chromium-Vanadium Steels, Norm	67	35	High Carbon Steels, H & T	13.5	8.5
Nitriding Steels, H & T (1200 F)	65	—	Tin Bronzes (cast), Leaded	12	4
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels, H & T (1200 F)	61	38	High Carbon Steels, HR	11	7
Manganese Steels, Ann.	52	—	Red & Semi-Red Brasses (cast), Leaded	9	3
Chromium-Vanadium Steels, H & T	50	37	Magnesium Alloys (cast)	5	4
Carbon Steels (cast), Ann.	30	—	Tin Bronzes (cast), High-Leaded	5	3
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels, Norm	27	21	Magnesium Alloys, Sol'n Tr	4.5	0.5
			Magnesium-Thorium & Magnesium-Zirconium Alloys (forged)	4	1
			Magnesium-Thorium & Magnesium-Zirconium Alloys (sand cast)	2.3	0.7
			Lead-Tin-Antimony (chill cast)	1.8	0.7
			Magnesium Alloys (cast), Sol'n Tr	1.5	0.5

[a]Values in this table are not directly comparable to those for Plastics (below) because the methods of computing test results differ.

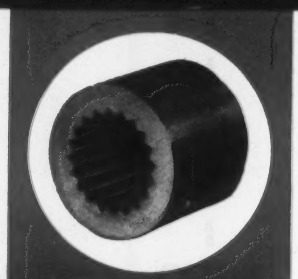
Impact Strength of Plastics

Notched Izod, ft-lb/in.

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Phenolics, Very High Shock Res	22	11	Plastics Laminates, Mech	1.6	1.4
Nylon, Soluble	>16	—	Cellulose Acetate, Hard	1.5	1.1
Polycarbonate	14	2	Cellulose Acetate Butyrate, Hard	1.5	0.9
Polyvinyl Formal	10	10	Nylon 66	1.5	0.5
Plastics Laminates, Elec	10	4	Acetal	1.4	—
Alkyds, High Str	10	2	Melamines, Intermed Shock Res	1.3	0.2
Mod Polystyrene, Extra High Impact	9.9	5.1	Nylon 610	1.1	0.5
Melamines, Glass Fiber-Filled	8	4	Polypropylene	1	—
Plastics Laminates, GP	7.7	6.7	Polyvinyl Butryral	0.93	0.19
Polyesters (cast), Nonrigid	>7	—	Diallyl Phthalate, Orlon-Filled	0.85	0.35
Polyethylene, High Density	6.5	5.5	Polyvinylchlorides	0.73	0.47
Polysulfide-Epoxy (cast)	6	4	Melamines, Low Shock Res	0.7	0.2
Cellulose Nitrate	6	1	Epoxy (cast)	0.53	0.17
Cellulose Propionate	5.9	5.1	Hard Rubber	0.40	0.13
Ethyl Cellulose, High Impact	5.3	1.7	Acrylics	0.4	0.1
Vinylidene Chloride	5	3	Methylstyrene Acrylonitrile	0.40	—
Silicons, High Impact	4.5	1.5	Mod Polystyrene, Ht & Chem Res	0.38	0.12
Phenolics, High Shock Res	4.3	3.7	Diallyl Phthalate, Asbestos-Filled	0.38	0.07
Cellulose Acetate Butyrate, Soft	4.0	1.4	Phenolics, GP	0.37	0.13
Ethyl Cellulose, GP	3.9	2.1	Phenolics (cast)	0.34	0.11
Cellulose Acetate, Soft	3.6	1.6	Polystyrene, GP	0.33	0.07
Polytrifluorochloroethylene	3.6	—	Alkyds, GP	0.33	0.02
Diallyl Phthalate, Glass Fiber-Filled	3.3	2.7	Polymethylstyrene	0.33	—
Polytetrafluoroethylene	3.3	0.7	Melamines, GP	0.32	0.08
Diallyl Phthalate, Dacron-Filled	3.1	1.4	Silicons, GP	0.32	0.06
Nylon 6	2.4	1.1	Ureas	0.30	0.05
Polystyrene, Glass Fiber-Filled	2.0	0.5	Polyesters (cast), Rigid	0.29	0.11
Mod Polystyrene, High Impact	2	1	Allyls (cast)	0.25	0.07
Nylon, Glass Fiber-Filled	2	—	Vinylidene Chloride, Oriented	0.05	—
Phenolics, Shock & Ht Res	1.9	1.6			

◀ For more information, circle No. 489

Another Meta-Dynamics Division development in *"Chipless machining"!*



Ratchet
Material—AISI C-1020
Operation—Form I.D.
Production—300/hr.

Heat exchanger tubing
Material—Copper
Operation — Form fins
Production — 16″ of tubing formed per minute.

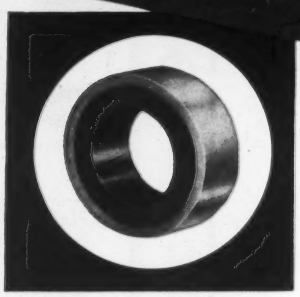
NEW CINCINNATI
Intraform

Rapidly produces complex internal profiles to close tolerances, with low cost tooling.

This new *chipless machining* method makes possible low cost production of parts having intricate I.D. profiles that would be difficult or time consuming to machine by conventional methods.

Hollow cylindrical stock, ferrous or non-ferrous, with open or blind holes, is placed over a mandrel and "kneaded" by rapidly pulsating, rotating dies. The smooth, continuous kneading action redistributes the metal to reproduce the profile of the mandrel in the I.D. of the part. The work is formed to close tolerances and with fine surface finish. Tensile strength and hardness of the metal are also improved.

Work diameters ranging from ⅛″ to 5″ can be cold formed on standard Cincinnati Intraform machines, which can also be used for bonding laminated tubing and for reducing and tapering solid or tubular stock. For a description of the process and its many advantages, write for Bulletin M-2060, or call in a Meta-Dynamics Division field engineer.



Laminated tubing
Material — Aluminum and copper
Operation—Bond copper lining to aluminum tube
Production — 24″ of tubing bonded per minute.

Left photo shows workpiece prior to Intraform operation. Note mandrel in front of part. Right photo shows workpiece after Intraform operation with profile of the mandrel reproduced in I.D. As workpiece feeds and mandrel does not, only a short, relatively inexpensive mandrel is required. Time for this operation was 16 seconds.

Intraform
META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

What's new IN MATERIALS

Edited by
John A. Mock

***Plasma arc torch** can be used to fabricate . . .*

***. . . shapes like these** out of virtually any material that melts.*

Plasma Arc Torch Fabricates Tough Materials

It can also be used for applying coatings

■ What is described as a radically new method for fabricating shapes and applying coatings that will withstand temperatures above 5000 F has been announced by Linde Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. Key to the method is a plasma arc torch that can melt the toughest materials known to man without itself being consumed by the intense heat it generates (up to 30,000 F).

Linde does not plan to market any equipment at this time, but is accepting orders for parts coating and fabrication either in production or in experimental quantities.

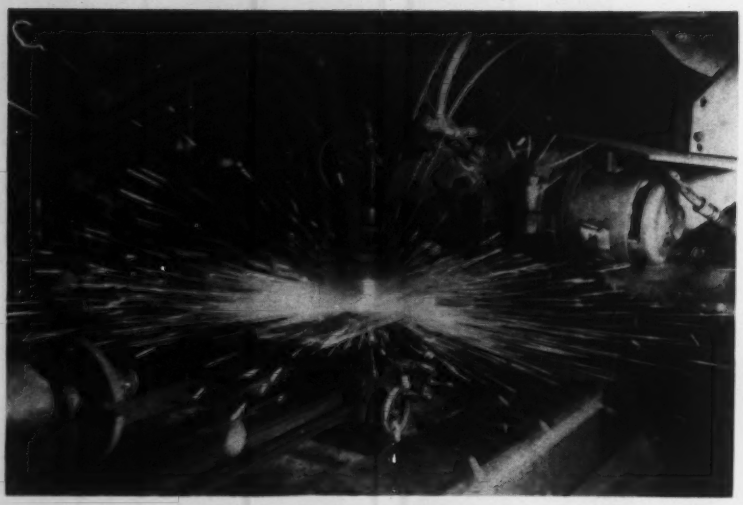
Fabricated parts

Linde's plasma arc torch has been used to fabricate pure tungsten rocket and missile parts, and tungsten crucibles for metallurgical purposes. The torch has also been used to fabricate nuclear reactor parts, electrical contacts, electronic parts and x-ray targets. According to Linde, the plasma arc torch can fabricate parts of any shape or size to close dimensional tolerances (± 0.0002 in.).

How parts are made: In fabricating, a mandrel is first built to the precise internal diameter of the part to be made. The mandrel is chucked on a wheel and spun. The torch applies successive coatings of a material to the spinning mandrel until desired thickness is reached. The mandrel is leached out in either nitric acid or caustic. Once made, parts are given a moderate heat treatment to improve density and other physical properties. Parts may or may not require additional polishing or grinding, depending on their use.

Linde says virtually any material that melts and hardens again can be fabricated. Soft aluminum

For more information, circle No. 426



***Coating stainless steel** on aluminum with a plasma arc torch. Aluminum plate being coated moves back and forth on a traverse.*

Plasma Arc Torch— How It Works

In a plasma arc torch, an electric arc column is forced to operate within a small diameter tube through which passes part of the arc and a flow of gas. Material to be worked is prepared in either wire or powder form and passed through the arc that reaches temperatures up to 30,000 F.

Because of the high heat of the arc, material passing through it is converted into a fluid. The liquid material is carried out of the torch by inert gases flowing at speeds up to 10,000 mph and deposited on a form or a part being coated with such force that a firm bond results.

can be fabricated as easily as hard tungsten carbide.

Coatings

Where formed parts are not required, the plasma arc torch can be used to coat virtually any material, including reinforced plastics.

Coatings applied with the plasma arc torch are said to be unique and quite different in appearance and character than those made by other processes. Bonds of plasma arc coatings to the base material are generally chemical and mechanical in character and are said to be much stronger than bonds obtained by electroplating, vapor depositing or metal spraying. Plasma arc coatings are very dense and are usually laminar in structure. They may be finished to below 10 μin.

The torch has been used successfully to coat rocket nozzles, jet vanes, rocket thrust chambers and thermocouples. It has also been used to coat such electronic parts as tungsten heaters, grid bars, targets and cathode cups.

Materials that may be deposited as coatings include:

1. Refractory metals such as tungsten, tantalum, molybdenum, columbium and rhenium.
2. Some of the refractory metal compounds, such as borides of zirconium, tungsten, columbium, tantalum, titanium and chromium.
3. Refractory carbides of columbium, hafnium, tantalum, zirconium, titanium, tungsten and vanadium.
4. Refractory oxides of thorium, hafnium, magnesium, zirconium, cerium and aluminum.
5. Noble metals: platinum, palladium and others in this group.

Magnesium Sheet Alloy Needs No Stress Relieving

■ Magnesium sheet alloys usually require stress relief after welding to prevent stress corrosion cracking. This expensive step is avoided in ZE10A, a new magnesium sheet alloy developed for room temperature service by Dow Chemical Co., Magnesium Dept., Midland, Mich. The alloy is said to have good weldability and is readily formed.

Dow Chemical is supplying the alloy as sheet and plate in the H24 and O tempers. The material is normally shipped with a mill finish. However, sheet with an acid pickle, chrome pickle or mill prime surface is offered.

Potential uses

Elimination of the need for stress relief after welding makes the alloy advantageous in very large structures and in field repair operations. Potential uses for the alloy include storage containers, shipping containers for commercial bulk products, and tank-trailer bodies.

Properties

The new alloy is generally comparable to the established room temperature sheet alloy AZ31B. The properties of these two alloys are given in an accompanying table. Other characteristics of ZE10A are given below.

Toughness: Tests show that ZE10A sheet alloy has the best toughness of any magnesium sheet alloy currently available. For example, the energies required to

fracture ZE10A sheet with either impact or static loading were 120 to 150% of the energies required to fracture AZ31B sheet of the same gage and temper.

Poisson's ratio: In the fully elastic region Poisson's ratio is 0.34; in the plastic region it is 0.50.

Fatigue life: Non-welded sheets of ZE10A have a fatigue life comparable to that of non-welded AZ31B sheets. Welded AZ31B sheets have greater fatigue life than welded ZE10A sheets.

Corrosion resistance: Alloy ZE10A has about the same corrosion resistance as AZ31B. However, ZE10A when immersed in 3% sodium chloride at 95 F for 7 days is more susceptible to localized or pitting type of attack than AZ31B. Measurements of the loss of tensile strength due to exposure indicates that both alloys have equivalent atmospheric corrosion resistance.

Fabrication

Dow engineers give the following points for machining, forming, bending, welding and treating the alloy.

- ZE10A has about the same machinability characteristics as other magnesium alloys.
- The alloy is readily formed under the same conditions as AZ31B sheet, although the maximum allowable forming temperatures for 1-hr exposure are slightly lower than for AZ31B. Alloy ZE10A has been successfully deep drawn and formed into a number of commercial parts.
- Limited laboratory test results show that the suggested bend radius for ZE10A sheets is the same as that for AZ31B sheets of the same temper.
- Alloy ZE10A is easily welded using AZ92A, AZ61A or EZ33A welding rod. Back-up plates may be required in special cases when AZ92A or AZ61A rod is used.
- All standard chemical treatments can be applied to ZE10A sheet.

PROPERTIES OF MAGNESIUM ALLOYS COMPARED

Type →	AZ31BH24	ZE10AH24
COMPOSITION, %	Al 2.5-3.5, Zn 0.6-1.4, Mn 0.20 min	Zn 1.0-1.5, rare earths 0.12-0.22, other imp. 0.30 max
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.0640	0.0634
Melting Temp Range, F	1050-1170	1100-1200
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	43.6	77.0
Spec Ht, Btu/lb/°F	0.25	0.25
Elec Res, microhm-cm	9.2	5.2
MECHANICAL PROPERTIES		
Ten Str, 1000 psi	42	38
Yld Str, 1000 psi	32	28
Elong (in 2 in.), %	15	12
Compr Yld Str, 1000 psi	26	26

Aberdeen Proving Ground

Trailer body, *such as the Army Ordnance radar van shown here, is a potential use for Dow's new magnesium alloy.*

Two Stainless Steels for High Temperatures

■ Two new stainless steels—an austenitic stainless with good strength at 1600 F, and an easily welded 12% chromium martensitic stainless—have been developed by Armco Steel Corp., Middletown, Ohio and Carpenter Steel Co., Reading, Pa., respectively.

The austenitic stainless, designated Armco 22-4-9, is said to be hard, strong and corrosion resistant at temperatures up to 1600 F and is expected to find usage in high temperature steam valves and gas turbine parts. It is presently available in the form of forging billets and rounds from ⅜ to 3 in. incl.

The martensitic stainless, designated Carpenter 404, is a hardenable alloy developed for highly stressed parts at temperatures up to 1050 F where joining is a problem. It is designed to be free from weld cracking without preheating or postheating and is recommended for steam turbine buckets, bucket covers, blades and diaphragms.

Armco 22-4-9

Chief alloying elements in this steel are chromium, manganese

PROPERTIES OF ARMCO 22-4-9[a]

Temperature →	Room	900 F	1100 F	1200 F	1400 F	1600 F
Ten Str, 1000 psi	102	114	100	86	62	38
Yld Str, 1000 psi						
0.2% offset	102	58	53	48	37	25
0.02% offset	77	—	—	—	—	—
Elong (in 2 in.), %	9	20	18	16	18	27
Red. of Area, %	9	21	24	23	25	39
Hardness, Brinell	344	236	218	205	194	177
Stress (1000 psi) for Rupture in						
100 Hr	—	100	61	—	23	—
1000 Hr	—	83	50	—	10	—
Fatigue Strength, 1000 psi						
21,000 Cycles	—	—	—	50	—	—
64,227,000 Cycles	—	—	—	30	—	—
Impact Str (Charpy V-notch), ft-lb	11	—	—	—	—	62

[a]Heat treated and aged bar stock. Physical properties are: coef of ther exp (70-1600 F), 10.43 x 10⁻⁶; ther cond, Btu/hr/sq ft/ft/°F, 12 (900 F), 15 (1600 F); density, 0.279 lb/cu in.

COMPOSITION OF 22-4-9, %

Carbon	0.45-0.60
Manganese	7.00-10.00
Phosphorus	0.045 max
Sulfur	0.12 max
Silicon	1.00 max
Chromium	20.00-23.00
Nickel	3.00-5.00
Nitrogen	0.30-0.50

and nickel (see composition table). The composition is such that the steel remains austenitic in all conditions.

According to Armco, room temperature hardness of the new alloy can be controlled between 300 and 550 Bhn, depending on method of processing. Added room temperature hardness may be achieved by working at elevated temperature ("cold" work). For example, by finishing at 1600 F, room temperature hardness values of up to Rockwell C50-55 have been developed.

With an initial room temperature hardness of 344 Bhn, the new steel has exhibited a hot hardness of 250 Bhn at 1100 F after 1000 hr at this temperature. Because of its high room and elevated temperature hardness, 22-4-9 is said to be more resistant to wear, erosion, galling and seizure than other austenitic materials.

The new alloy is nonmagnetic (maximum permeability is under 1.02) and is said to be useful for such applications as nonmagnetic balls and roller bearings.

Heat treatment, properties

The standard heat treatment for Armco 22-4-9 involves solution treating 1 hr at 2150 F, water quenching, then aging 14 hr at 1400 F and air cooling. In this condition the microstructure shows a finely dispersed intergranular and intragranular carbide precipitate with an austenitic matrix.

Typical room and elevated temperature properties of heat treated bar stock are given in the accompanying table.

Fabrication

Machining—It is recommended that machining be done either in the hot rolled condition or after heat treatment. When machining is done in the solution treated condition, the material is found to be gummy. Also, the work hardening rate under the tool is much greater. Machining is best done with carbide-tipped tools. To facilitate machining, 22-4-9 is made with a sulfur content of 0.12% max.

Cutting—Cutting is best done with lubricated abrasive disks or by hot shearing.

Forging—Armco 22-4-9 is readily hot forged or upset forged. The initial forging temperature may range from about 2000 F to 2400 F, depending on size of stock, the part design and the amount of work to be done. The smaller the cross section of the billet or bar, the higher the temperature that may be used without damage from overheating.

Because of the relatively high carbon content of this alloy care must be exercised to avoid decarburization. Long-time use at the soaking temperature is to be avoided. Induction heating is recommended, and electric muffle furnaces with an air atmosphere

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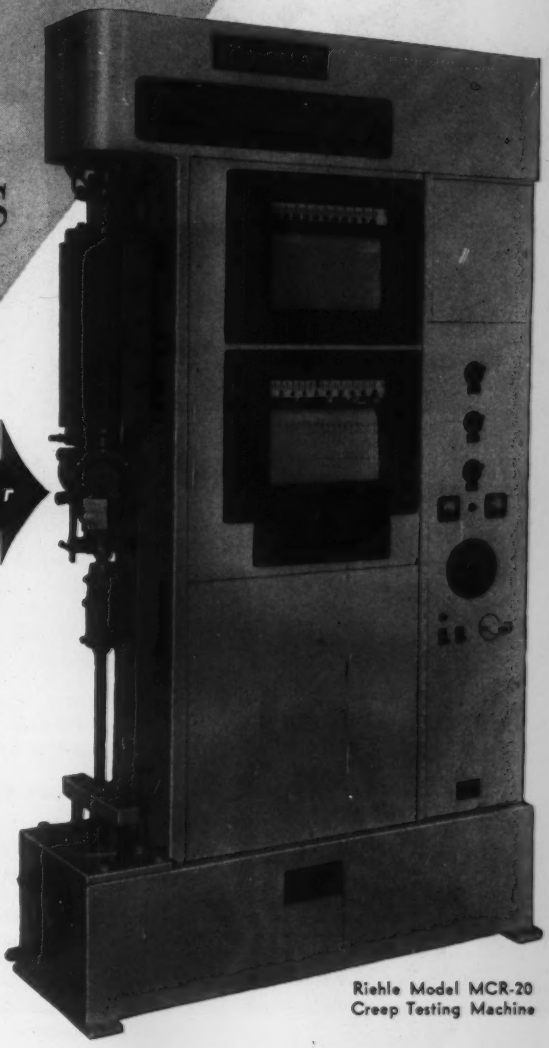
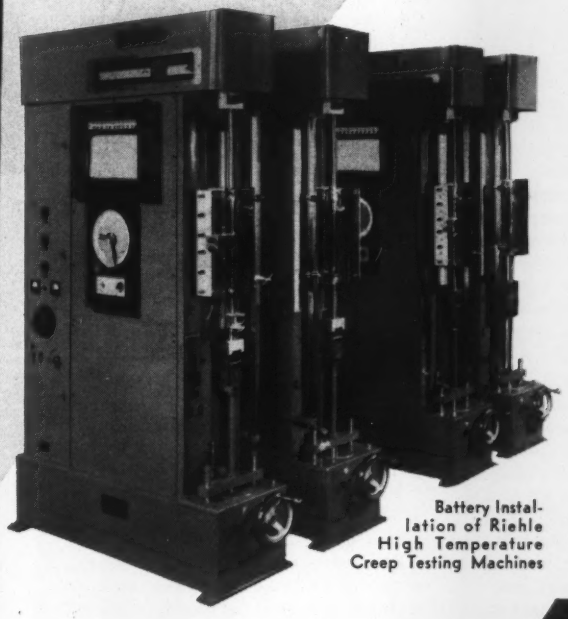
High temperature creep and relaxation TESTING MACHINES . . . complete from RIEHLE®

New High Temperature Extensometer

Riehle extensometers are available in 28 different models to accommodate various specimens and temperatures up to 3500°F. Measuring ranges are from 0.1" to 0.5" and magnification ratios are from 20 to 1250, depending upon the type of recorder used.



Riehle Model MCR-20
Creep Testing Machine



Battery Installation of Riehle
High Temperature
Creep Testing Machines

Using only 33-1/3 lbs. of weights, this Riehle Model MCR-20 features a multiple lever loading system to provide testing loads in increments of 1,000 lbs. A sliding poise and beam graduated in units of 10 lbs. provides intermediate loads.

Riehle creep and relaxation testing machines are available in high temperature ranges of 1850°, 2200°, 3000° and 3500°F., and in capacities up to 450,000 lbs., as specially instrumented universal testing machine.

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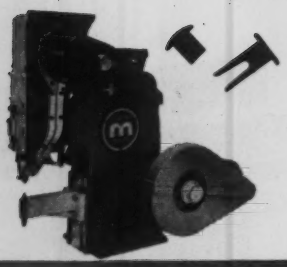

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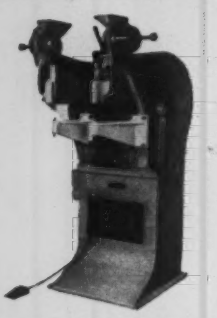

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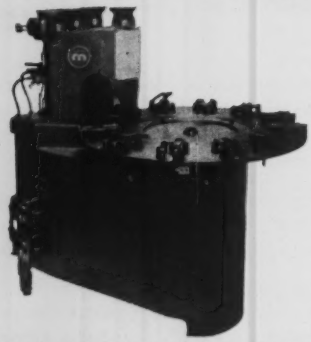

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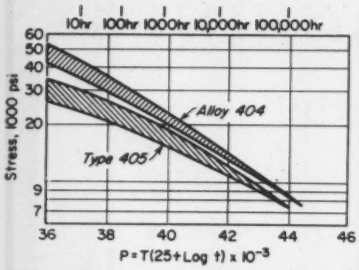

***Fig 1**—Stress-rupture properties at 1000 F: Carpenter alloy 404 vs 405 stainless.*

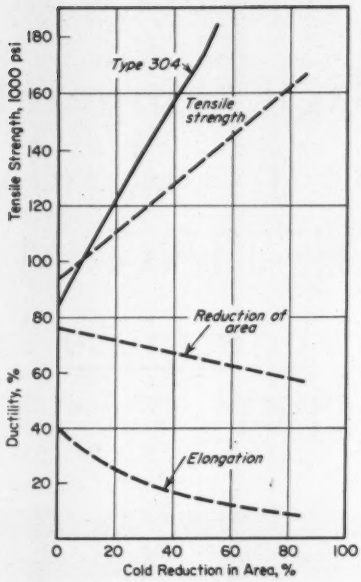

***Fig 2**—Effect of cold reduction on tensile properties of alloy 404.*

are more desirable than oil or gas-fired furnaces.

Welding—Armco 22-4-9 is a weldable alloy and can be joined by any of the methods used for stainless steel. Because of its austenitic structure, this alloy can be welded without preheating or postheating and is not susceptible to cracking.

Carpenter 404

According to Carpenter, the 404 alloy was developed to solve the problems of weld cracking and embrittlement in hardenable 12% chromium alloys. It was felt that a fully martensitic alloy with a maximum as-quenched hardness of Rockwell C36 would solve the problem. Experimental work showed that keeping carbon and nitrogen contents at low levels (see composition table) keeps hardness to a minimum and prevents cracking. However, other austenitizing elements—nickel and manganese—had to be added to insure a fully martensitic structure after treating and welding.

Properties, fabrication

The new steel has good tensile strength and ductility (see Fig 3) and, according to Carpenter, has better weldability than 410 stainless. In the annealed condition, alloy 404 is said to be easily blanked, drawn, formed or cold headed. And it is readily machined in both the heat treated and annealed conditions.

The alloy offers resistance to a wide range of corrosives, including the atmosphere, fresh and mine water, steam, oil, gasoline, alcohol, etc. It also has good resistance to scaling at elevated temperatures and can be used continuously at temperatures up to about 1200 F.

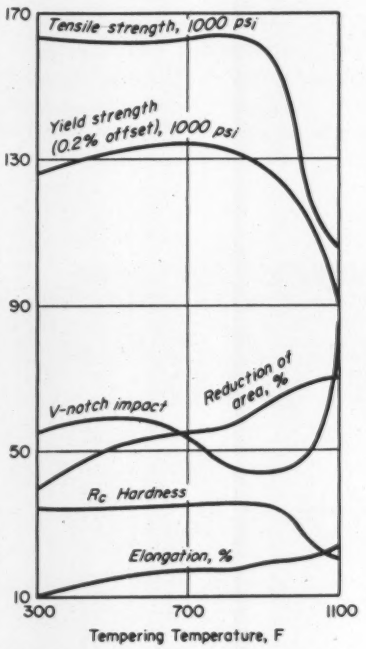

***Fig 3**—Effect of tempering temperature on properties of alloy 404.*

Stress-rupture properties of Carpenter alloy 404 as compared to 405 stainless are given in Fig 1, and the effects of cold reduction on tensile properties of alloy 404 are given in Fig 2.

To obtain optimum properties, alloy 404 is annealed to 1200-1300 F, soaked 2-4 hr and air cooled; and

For more information, circle No. 490 ➤

AGAIN

P-K Internal-Fin Coolers can be furnished insulated with Rock Cork laid in asphalt and covered with a heavy steel jacket. Illustration shows insulated cooler.

Revere helps fit the metal to the job

AND PATTERSON-KELLEY CUSTOMERS SAVE 3 WAYS

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With the P-K Type FO Internal-Fin Freon 22 Water Cooler the installation can be designed for a shell 2 diameters less and 1 to 2 feet shorter than with conventional plain or bare tube coolers. This is made possible by the use of ¾" O.D. x .035" gauge Revere copper tube drawn over a Revere aluminum extruded fin as shown above. Serrated surface of the fin enhances refrigerant vaporization.

By making both the tube and the extruded fin, and assembling them in the same plant a tight contact between the two metals is assured, thus establishing maximum heat transfer. Once again Revere has helped fit the metal to the job, money was saved and a more efficient product produced.

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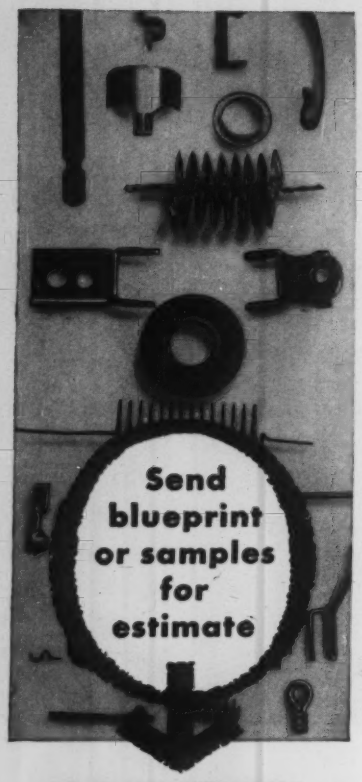

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COMPOSITION OF CARPENTER 404 ALLOY, %

Carbon	0.05 max
Manganese	1.00 max
Phosphorus	0.030
Sulfur	0.030 max
Silicon	0.50 max
Chromium	11.00-12.50
Nickel	1.25-1.75
Nitrogen	0.03 max

hardened by heating to 1750-1850 F, soaked and oil quenched.

Availability

Forms now available include forging billets, hot rolled bars and forgings (either annealed or heat treated), cold drawn and ground bars, wire and wire rods, and strip (annealed or tempered).

Thin electrical tapes possible with . . .

TFE Molding, Extrusion Resin

■ Volume production of Teflon 7, a new TFE molding and extrusion powder granulated to ultra-fine particle size, has been announced by E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., Wilmington 98, Del. Cost of the material is $5 per lb in lots of 24,000 lbs or more.

According to Du Pont, the material can be extruded into electrical tapes as thin as 1 mil. Previously, the thinnest electrical tape of TFE resin was 2 mils. In addition, Teflon 7 can be molded into tubes, gaskets and pump diaphragms. It can also be used to line pipes and tanks.

Properties

Du Pont has been gathering data on the thermal, chemical and electrical properties of the resin ever since its introduction in 1955. Here is a summary of that data:

Thermal properties: Parts made of Teflon 7 can be used continuously at temperatures as high as 500 F and intermittently at higher temperatures. Molded and extruded parts have good low temperature toughness and retain some flexibility at temperatures as low as –450 F. Teflon 7 is a crystalline material at temperatures up to 621 F and an amorphous gel above this temperature.

Chemical properties: Teflon 7 is completely inert to nearly all chemicals and solvents. Exceptions are attack by the alkali metals, fluorine and certain rare fluorine compounds under particular conditions. At high temperatures and pressures, certain halogenated hydrocarbons can produce slight physical swelling. For instance, carbon tetrachloride causes a 1.5% increase in volume after aging 6 hr at 300 F.

Electrical properties: Power factor of Teflon 7 is less than 0.0003 over the entire spectrum measured to date (60 cps to 3000 mc). Volume

***Pipe linings** as well as electrical tapes are potential uses for Du Pont's new TFE molding and extrusion resin.*

SPRING STRESSES that formerly required premium-priced materials can now be handled by Duraflex,® which costs no more than regular phosphor bronze. Write for literature and samples, today.

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August 1, 1958

The American Brass Company
414 Meadow Street
Waterbury, Connecticut

Gentlemen,

SUMMARY OF ENGINEERING LABORATORY REPORT No. 8158

SUBJECT: Fatigue Life and Endurance Limit testing of; "DURAFLEX" Superfine-Grain Phosphor Bronze and Commercial Quality Phosphor Bronze, 5% (A) spring quality strip material.

SPRINGS: Flat spring strip was made into the usual type of contact springs used in switches, relays and instruments. These springs were deflected at about 1 cycle per second in a specially built fatigue testing machine and the deflections recorded.

STRESSES: The springs were deflected from the initial free position of zero stress to a final position having a bending stress of 77,000 p.s.i.

This stress, for phosphor bronze strip is unusually high and is higher than stresses ordinarily recommended for Beryllium-Copper or Stainless Steel for such severe service.

RESULTS: Commercial Quality Phosphor Bronze, 5% (A) springs acquired a permanent set quite early and broke at an average number of deflections of 453,374.

"DURAFLEX" springs were still satisfactory, showed no permanent set, no loss of load and no breakage at 4,000,000 deflections.

CONCLUSION: Design stresses for "DURAFLEX" can be at least 50% higher than the stresses for Commercial Quality Phosphor Bronze, 5% (A) as shown in the TOOL ENGINEERS HANDBOOK.

Respectfully submitted,

THE CARLSON COMPANY

Harold Carlson

Harold C. R. Carlson, P.E.
Licensed Professional Engineer

LICENSED PROFESSIONAL ENGINEER HAROLD C. R. CARLSON NO. 25571 STATE OF NEW YORK

HC:R

THREE SPRINGS of regular Phosphor Bronze, 5% (A), actual size, took a permanent set at about 200,000 deflections and fractured at an average of 453,374 deflections.

FOUR SPRINGS of Duraflex Superfine-Grain Phosphor Bronze, 5% (A) were still satisfactory after 4,000,000 deflections.

DURAFLEX, available in Phosphor Bronzes (A), (C) and (D), in strip and wire, offers a host of opportunities to cut costs while maintaining or improving quality and performance. For further information and technical help to select the alloy to meet your needs—call in your American Brass Company representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6938

DURAFLEX
SUPERFINE-GRAIN PHOSPHOR BRONZE
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Made by The American Brass Company

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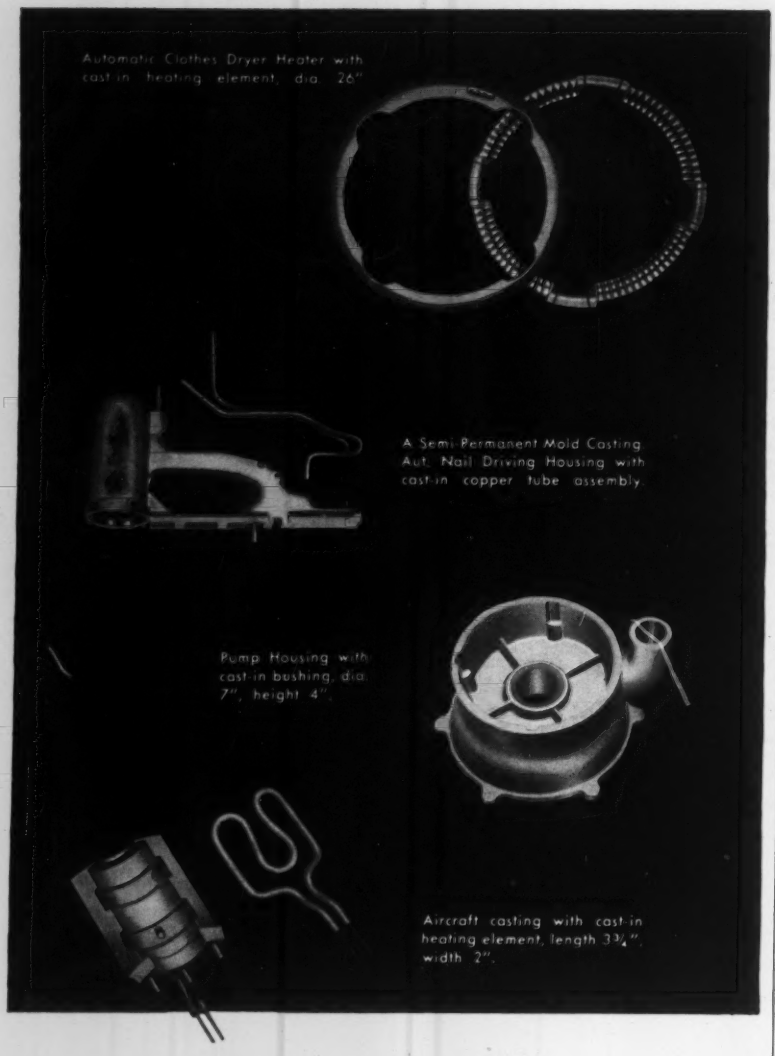
Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"
A Semi-Permanent Mold Casting Aut. Nail Driving Housing with cast-in copper tube assembly
Pump Housing with cast-in bushing, dia. 7", height 4"
Aircraft casting with cast-in heating element, length 3¾", width 2".

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Your product design requirements may dictate a light weight, rust-proof casting, tailored to perform with a heating element, bushing or insert. ALUMINUM PERMANENT MOLD casting is the answer, as it is superior to other casting methods for holding and positioning metals selected for integral performances.

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PROPERTIES OF TEFLON 7

PHYSICAL PROPERTIES	
Specific Gravity	2.16
Flammability	Noninflammable
Coef of Ther Exp, per °F	5.5×10^{-5}
Ther Cond, Btu/hr/sq ft/°F/in.	1.7
Water Absorption, %	<0.01
Specific Heat, Btu/lb/°F	0.25
MECHANICAL PROPERTIES	
Izod Impact Str, ft-lb/in.	
—70 F	2.0
73 F	3.0
170 F	6.0
Tensile Strength, psi	4000
Elongation, %	350
Flexural Strength, psi	No Break
Flexural Modulus, psi	70,000
Compr Str (1% offset), psi	1000
Heat Dist Temp (66 psi), F	250
Def under Load (122 F), %[a]	
1200 Psi	6
2000 Psi	25
Coef of Friction Against Steel	0.04
Durometer Hardness	D58
ELECTRICAL PROPERTIES	
Dielec Str (short-time), v/mil[b]	550
Vol Res, ohm-cm	10^{18}
Surface Res (100% RH), mc	10^{11}
Dielec Constant	
60 Cps	2.00
10^3 Cps	2.00
10^6 Cps	2.00
10^8 Cps	2.00
Dissip Factor	
60 Cps	<0.0003
10^3 Cps	<0.0003
10^6 Cps	<0.0003
10^8 Cps	<0.0003
Arc Resistance, sec	Does not track

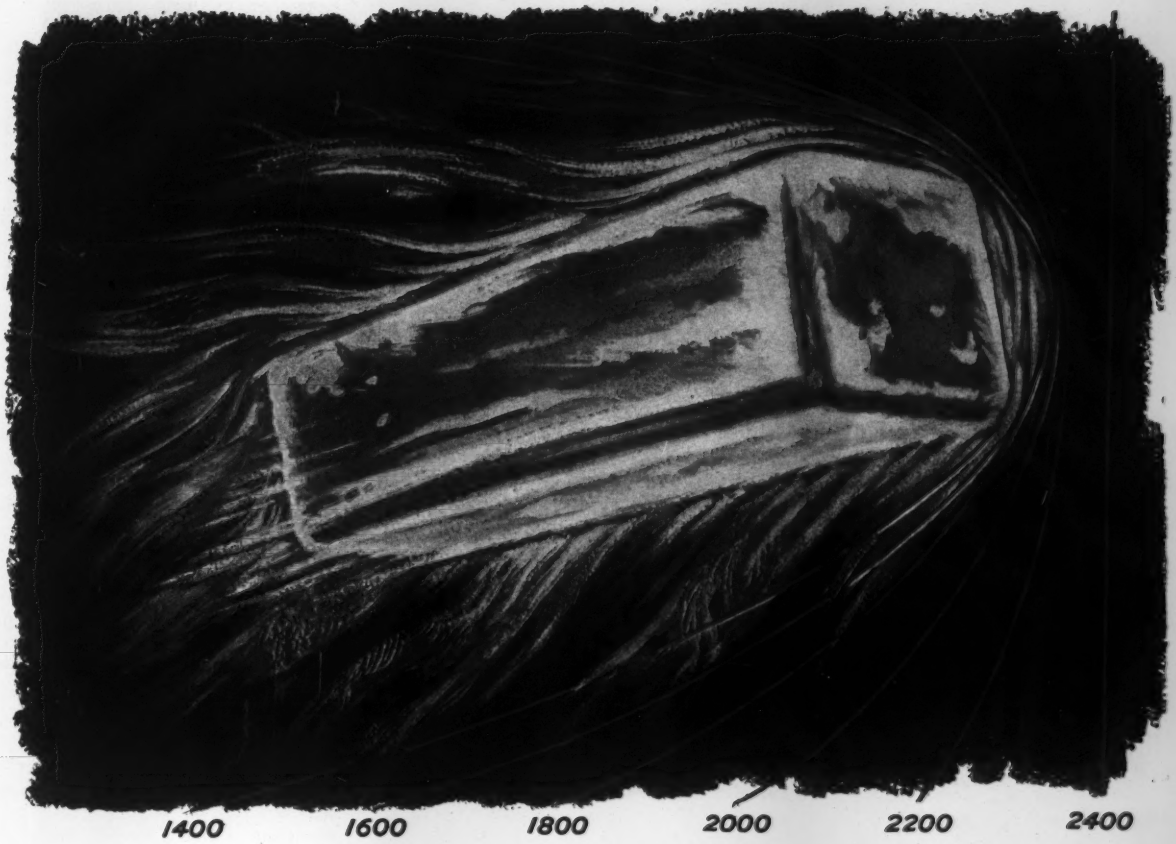
[a]Tested 24 hr.
[b]Tested on 0.080-in sample.

resistivity is greater than 10^{18} ohm-cm, even after prolonged soaking in water. Short-time dielectric strength ranges from 500 to 4000 v per mil, depending on thickness.

Teflon 7 also has good arc resistance. On exposure to an arc, the material decomposes to a vapor which leaves no carbonized path, regardless of time of exposure to the arc. Electrical properties of the resin are essentially unchanged up to 400 F, according to the developer.

Fabrication

Teflon 7 may be cold formed at room temperature and subsequently sintered at 700-740 F. Sintered parts may be coined for greater dimensional accuracy, or hobbed to form complex shapes. The material may be cold formed under pressures of



Bending the Heat Barrier

Specialized mill equipment is available at HAYNES STELLITE for rolling high-temperature alloys into a variety of shapes and sizes. Bar (above) is being produced on a 24-inch mill.

High strength plus resistance to oxidation, creep, thermal shock, and fatigue—are some of the properties that have helped to push the heat barrier back over the past 15 years. These are the properties found in HAYNES high-temperature alloys. Properties that make these alloys very useful in the 1000 to 2000+ deg. F. range.

Typical uses? The really hot spots in jet aircraft, ramjets, and missiles are some. Furnace components, heat-treating equipment, kiln liners are others. In fact, any part where long service life under severe high-temperature conditions is essential.

There are 12 HAYNES high-temperature alloys—available immediately in convenient forms that can be readily fabricated. For information on properties and prices, write for descriptive literature.

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ALLOYS

HAYNES STELLITE COMPANY
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United States Gasket

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

Plastics Division of GARLOCK

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800 to 5000 psi into preforms of unusual strength, according to Du Pont.

Five Titanium Alloys for Aircraft, Missiles

Mallory-Sharon Metals Corp., Niles, Ohio has developed five new titanium alloys. The company says the alloys will probably be useful for such aircraft and missile parts as exhausts, cowlings and skins.

Of the five alloys, one keeps its strength at temperatures up to 1100 F, two have good welding characteristics, one is highly formable in the solution treated condition, and one can be heat treated to very high strength levels while maintaining good ductility.

MST 881

Titanium alloy MST 881 is said to be stronger than most steels at temperatures up to 1100 F for long periods and up to 1500 F for short periods.

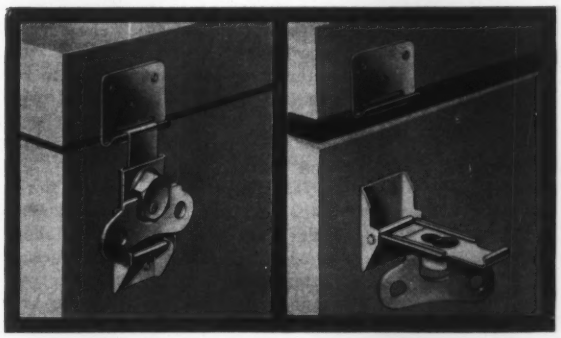
Composition: The alloy has a nominal composition of 8% aluminum, 8% zirconium, and 1% columbium and tantalum combined.

Mechanical properties: Typical room temperature mechanical properties of a ⅝-in. bar (vacuum annealed 4 hr at 1600 F and furnace cooled at 650 F) are: ultimate tensile strength, 145,000 psi; yield strength (0.2% offset), 125,000 psi; elongation, 16%; and reduction in area, 29%. The bar has an impact strength of 10 ft-lb per in. at -40 F.

High temperature properties: Comparative high temperature strength data on type 304 stainless steel, A-286 iron-base alloy, PH-15-7 Mo stainless steel, and MST 881 titanium alloy shows MST 881 has greater short-time tensile strength on a strength-weight basis than the two stainless steels and the iron-base alloy at temperatures above 600 F. MST 881 is stronger than type 304 stainless steel at temperatures up to 1500 F and above. Of the four alloys, PH-15-7 Mo stainless steel has the best strength properties at temperatures up to 800 F, whereas iron-base alloy A-286 has the best strength properties at temperatures from 800 to 1350 F. Above 1350 F,

Zero cases, sealed pressure-tight by **LINK-LOCK**,

Simmons No. 3 LINK-LOCK fasteners are employed on these deep-drawn aluminum Zero transit cases. LINK-LOCK is available in three sizes, for light, medium, and heavy duty.



No. 2 LINK-LOCK. Half turn applies high closing pressure, counter-turn disengages for opening.

guard instruments against humidity, dust, atmospheric pressure changes

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- Latch design can be varied to suit different applications.
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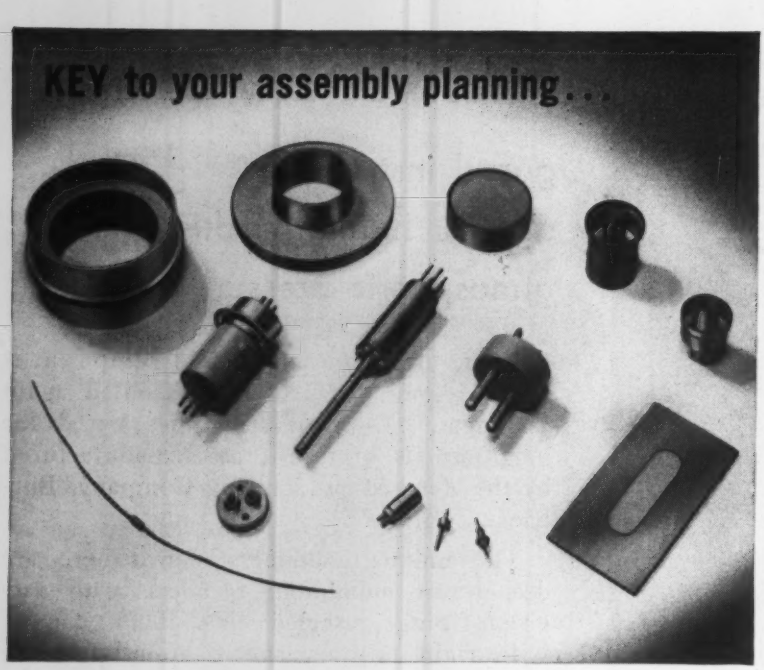

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. . . can be immersed in a wide variety of molten brazing alloys for extended periods of time.

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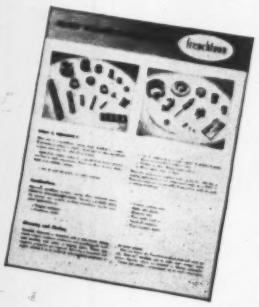
MOLCOTE surfaces are supplied ready for use for soldering and brazing applications in any temperature range up to 2000° F. MOLCOTE bonds are exceptionally strong with a tensile strength exceeding 10,000 psi.

Frenchtown Engineering Bulletin 1155 contains complete details and data on MOLCOTE Metallized Coating for Ceramics. We'd be pleased to send you a copy for use in your assembly planning. A good time to write for it is *NOW*.



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FRENCHTOWN, NEW JERSEY

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even without strength-weight considerations, MST 881 and A-286 have the same strength.

MST 881 on a strength-weight basis has better stress for rupture in 100 hr at 1000 F than type 304 stainless steel and A-286 iron-base alloy.

Thermal stability: MST 881, though containing 8% aluminum, has satisfactory thermal stability under creep conditions.

Weldability: Welding tests have not been completed, but it is expected that this alloy will be weldable.

Oxidation resistance: MST 881 has shown excellent oxidation resistance at temperatures up to 1100 F. Tests at higher temperatures are presently underway.

Availability: Titanium alloy MST 881 is available as bar; sheet production is presently in the experimental stage.

MST 2.5 Al–16 V

Described as an age hardenable sheet and bar alloy, MST 2.5 Al-16 V is highly formable in the solution treated condition and can be subsequently age hardened to high strength.

Composition: The alloy has a nominal composition of 16% vanadium and 2.5% aluminum.

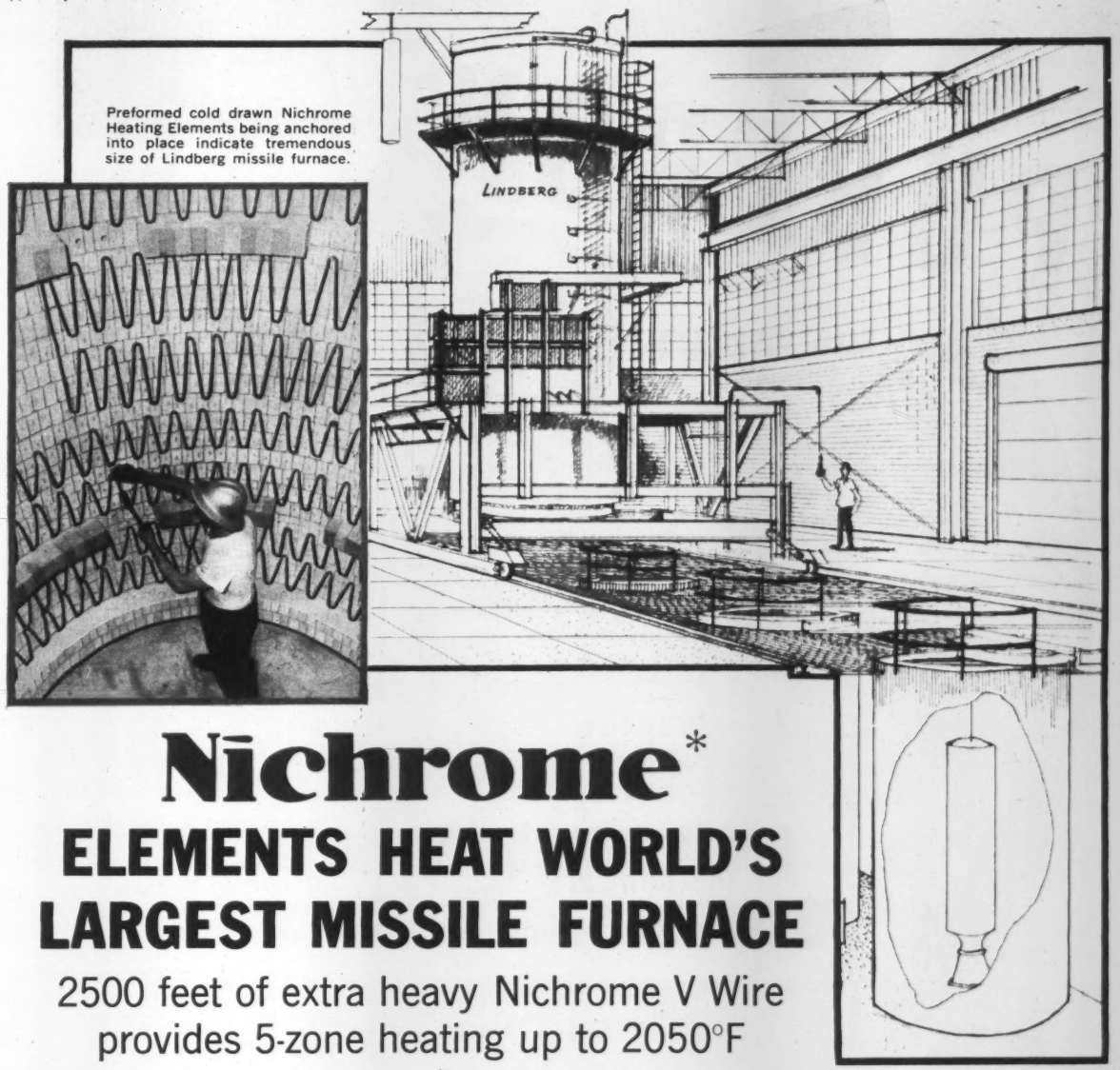
Mechanical properties: Typical room temperature mechanical properties of 0.063-in. thick sheet (solution treated ½ hr at 1400 F, then water quenched) are: ultimate tensile strength, 110,000 psi; yield strength (0.2%), 55,000 psi; elongation (in 2 in.), 15%; and minimum bend radius, $2T_R$.

Uses: Because of its easy workability and high strength after age hardening, MST-2.5 Al-16 V should be useful as a honeycomb structural material in aircraft. Its heat treatment cycle coincides with the brazing cycle for honeycomb structures, it has good ductility, and it is suited to continuous rolling processes necessary in the production of honeycomb structures.

Availability: The alloy is available in sheet, strip, bar, billet and wire.

MST 821

Titanium alloy MST 821 is a weldable sheet and bar alloy that has low density and good creep re-



Preformed cold drawn Nichrome Heating Elements being anchored into place indicate tremendous size of Lindberg missile furnace.

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In the hardening furnace there are five control zones which operate between 250°F and 2050°F. Saturable core reactors automatically vary the voltage to the Nichrome*V heating elements between 2.2 and 220 volts, depending on temperature and load.

The selection of Nichrome V by Lindberg to supply reliable and closely controlled heat and temperature in this furnace is further evidence of the confidence that industrial leaders have in the quality and performance of Driver-Harris high-nickel alloys. Why not benefit from their experience. Tell us about your requirements. *T.M. Reg. U.S. Pat. Off. †Lindberg Engineering Company

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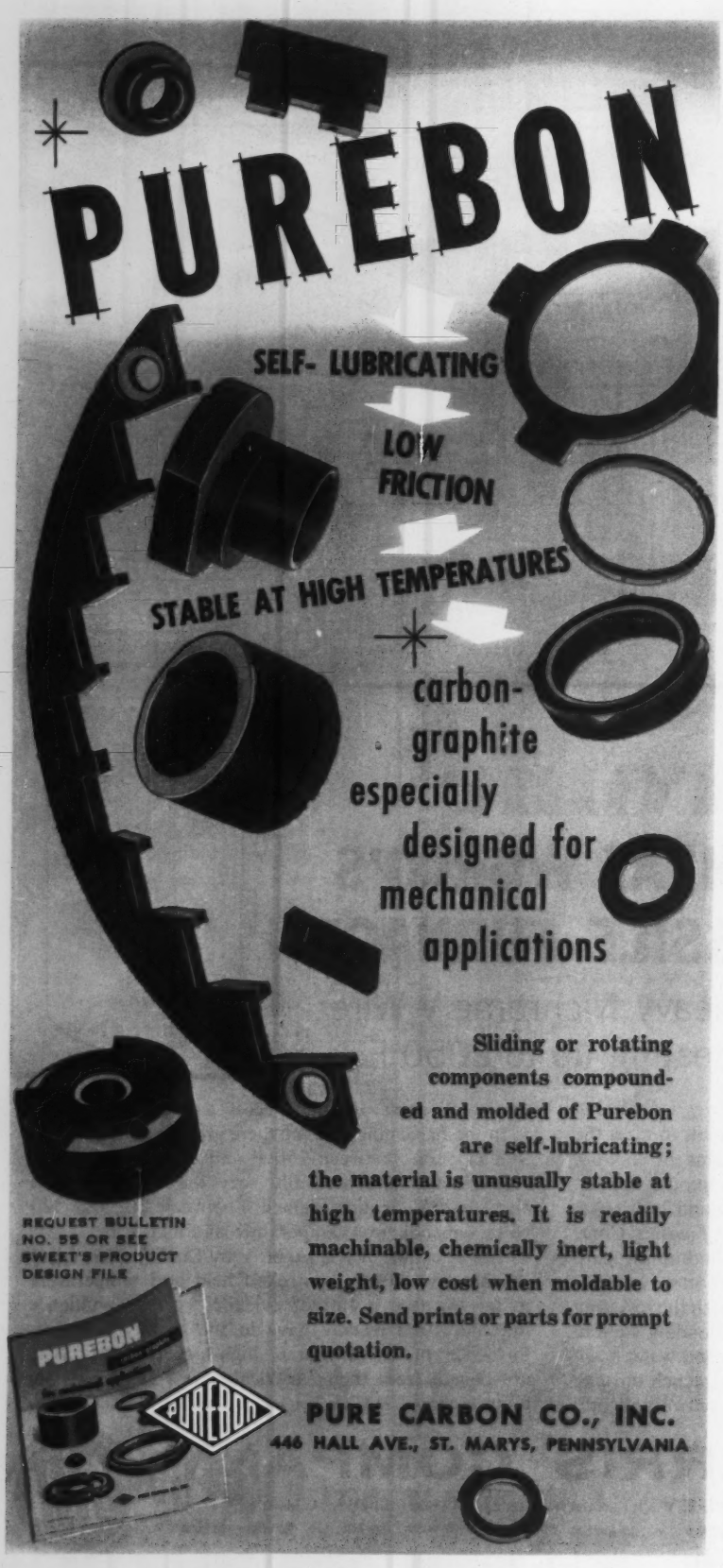
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sistance at high temperatures.

Composition: The nominal composition of the alloy is 8% aluminum, 2% columbium and 1% tantalum.

Mechanical properties: Room temperature mechanical properties of a ⅝-in. bar (annealed 1 hr at 1650, then air cooled) are: ultimate tensile strength, 136,000 psi; yield strength (0.2% offset), 130,000 psi; elongation (in 1 in.), 18%; Charpy impact strength, 24 ft-lb; and reduction in area, 45%.

Uses: When used as a forging material, MST 821 should be useful for jet engine rotors and blades.

Weldability: Tests indicate this alloy is readily welded with the same techniques used for commercially pure titanium.

MST 185

Mallory-Sharon says MST 185 was developed as a high strength, heat treatable sheet and bar alloy. It can be heat treated to very high strength while maintaining good ductility.

Composition: The alloy has a nominal composition of 8% vanadium, 5% iron and 1.3% aluminum.

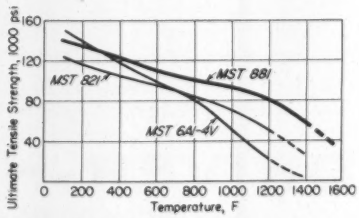
Mechanical properties: Room temperature mechanical properties of a 0.040-in. thick sheet (annealed ½ hr at 1250 F, furnace cooled to 900 F and air cooled) are: ultimate tensile strength, 177,000 psi; yield strength (0.2% offset), 167,000 psi; elongation (in 2 in.), 11.4%; and minimum bend radius $4T_R$.

MSM 3Al-2.5 V

Alloy MSM 3 Al–2.5 V is a medium strength, weldable alloy that can be fabricated into welded and seamless tubing, and welding wire.

Composition: The alloy has a nominal composition of 3% aluminum and 2.5% vanadium.

Physical properties: MSM 3 Al–2.5 V has a density of 0.162 lb per cu in., a melting point of approximately



***Strength properties** vs temperature for three titanium alloys.*

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Millers Falls Router Bits and Dyno-Mite high-speed power bits are revolutionary in concept, design and materials. They both perform with such unmatched efficiency that they have reached the "top-of-the-list" in their field.

Dependable, prolonged service is a "must" for all Millers Falls products and the component parts of both bits are therefore brazed with Silvaloy. The joints are as strong as the high-speed steels they join. Millers Falls uses Silvaloy 45 and Deoxo flux for these operations.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy Distributor for information or technical assistance. ★

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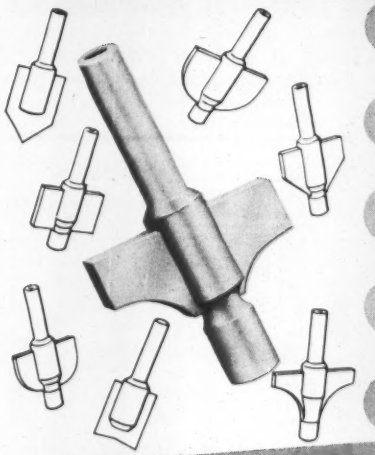

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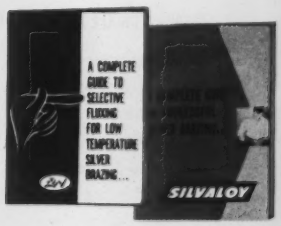

Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

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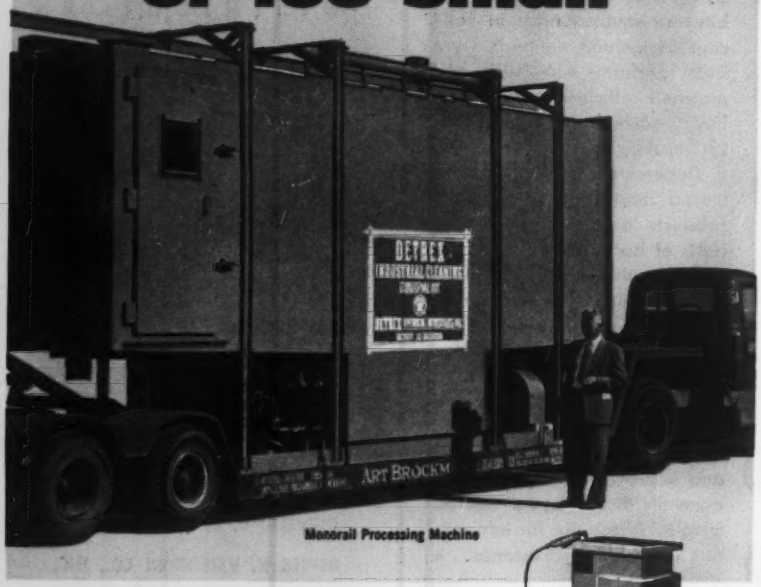
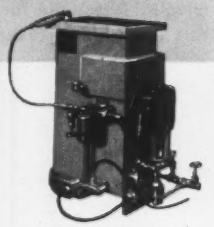


Monorail Processing Machine



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When DETREX equipment is applied to your specific needs, coupled with DETREX chemicals and DETREX service, you have the highest degree of quality and efficiency in the metal cleaning field. You can have it in your operation tomorrow. Find out about it today.

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- Solvent Degreasers
- Ultrasonic Equipment
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- Rust Proofing Materials
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- Spray Booth Compounds

DETREX CHEMICAL INDUSTRIES, Inc.

Box 501, Dept. MM-359, Detroit 32, Mich.

For more information, turn to Reader Service card, circle No. 492

What's new IN MATERIALS

3100 F, and a coefficient of thermal expansion of 5.16 x 10^{-6} per °F.

Mechanical properties: Room temperature mechanical properties of 0.040-in. thick sheet (solution treated ½ hr at 1300 F and air cooled) are: ultimate tensile strength, 83,000 psi; yield strength (0.2% offset), 80,000 psi; elongation, 21.6%; and min bend radius, $4.5T_R$.

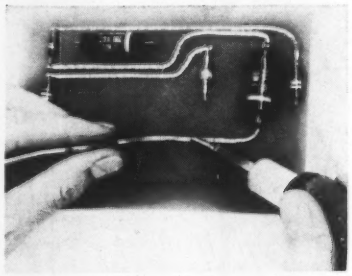
High temperature properties: Tests show a MSM 3 Al–2.5 V sheet has the following properties at 800 F: 56,000 psi ultimate tensile strength, 48,000 psi yield strength (0.2% offset), and 16% elongation (2 in.)

Rupture strength: Stress to produce rupture in 100 hr at 750 F is 50,000 psi.

Weldability: Tests on 0.040-in. sheet indicate MSM 3 Al–2.5 V can be welded with techniques now used for commercially pure titanium.

Safety Glazing: How Glass, Plastics Rate

Acrylic plastic safety glazing has greater impact resistance than other types of glass or plastics safety glazing. This fact was derived from

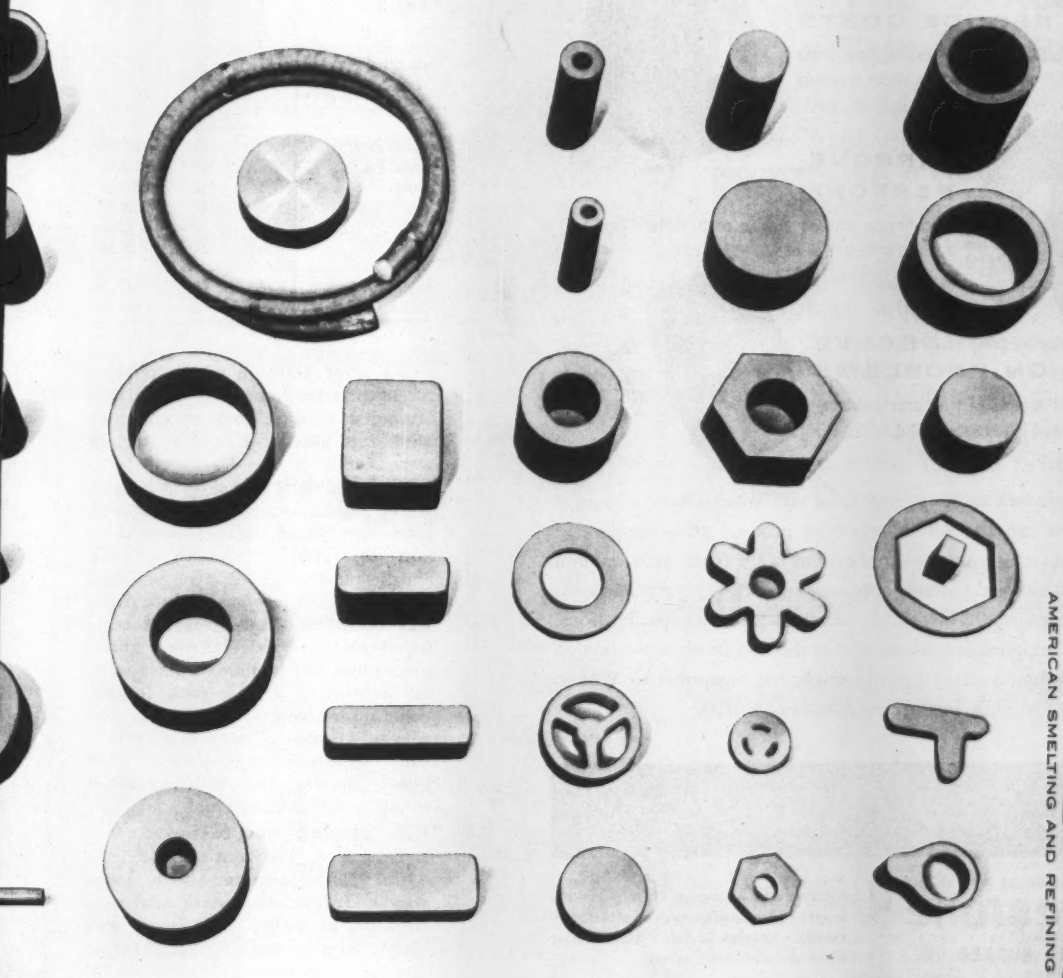


Easily applied printed circuits—Shown here is a resin-backed corrugated copper strip for printed circuitry. It can be easily applied to plastics laminates with regular soldering irons. Called Cir-Quik and developed by Redel Inc., 220 N. Atchison St., Anaheim, Calif., the corrugated construction of the strip is said to allow circuit lines to take any irregular shape. The resulting circuits can be punched, drilled and solder dipped without damage, according to the producer.

For more information, circle No. 434 ➤

In continuous lengths: the bronze casting you want in the shape you want! Asarco will custom cast practically all standard tin-bronze alloys in the shapes, lengths and diameters you need. Custom-shapes in long lengths instead of individual castings. Uniformity and machinability of bronze alloys with no hard or soft spots: no sand, dirt, or dross to dull tools or reduce cutting speeds. Superior physical characteristics: impact, tensile, and yield strength, and hardness, improved as much as 100% over the same alloys cast by other methods. Asarcon® 773 (SAE 660), general purpose bearing bronze, is immediately available from stock in 260 sizes, rods and tubes in ½″ to 9″ diameters, lengths up to 105″. Special shapes can be made to order. Write: Continuous-Cast Products Dept., American Smelting and Refining Company, Barber, N. J., Kingwell Bros., Ltd., 457 Minna St., San Francisco. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

CONTINUOUS-CAST DEPARTMENT OF



ASARCO

AMERICAN SMELTING AND REFINING COMPANY

8-17

REDUCE MANUFACTURING COSTS

IMPROVE PRODUCT PERFORMANCE

SOLVE DESIGN PROBLEMS

with

WORLD BESTOS

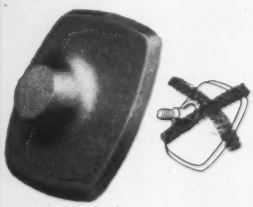
MOLDED ORGANIC PARTS

REDUCE COSTS

High-density molded organic part replaces brass pressure plate in clutch assembly

IMPROVE PERFORMANCE

Semi-flexible molded organic parts replace leather washers in deep well pump



SOLVE DESIGN PROBLEMS

Resilient molded organic part replaces combination metal-hard rubber vibration damper

● A fresh approach to design problems with WORLD BESTOS Molded Organic Parts can pay off in improved product performance and reduced manufacturing costs. Applications range from industrial and automotive equipment to home appliances. Molded Organic Parts can be built to meet virtually any shape, size or performance specifications. Parts can be supplied for testing and evaluation or on a production basis. For complete details, send samples or blueprints to WORLD BESTOS, New Castle, Indiana. Phone Jackson 9-4790.

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DIVISION OF THE Firestone TIRE AND RUBBER CO.

Industrial and Automotive Brake Blocks and Linings · Transmission Linings · Special Clutch Facings · Vibration Controls · Sheet Packing

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What's new IN MATERIALS

IMPACT RESISTANCE OF SAFETY GLAZING MATERIALS

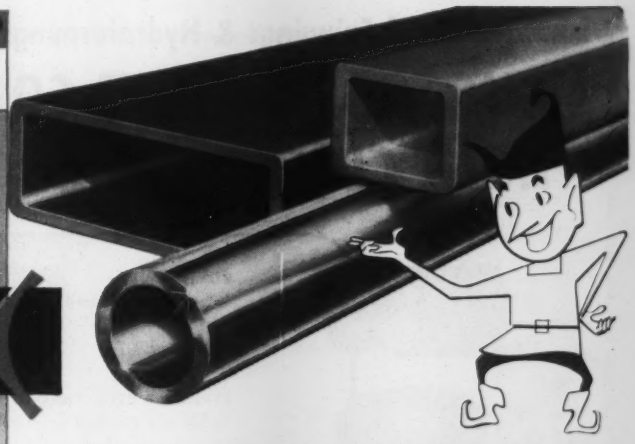
Material ↓	Wt of Ball, lb	Ht of Drop, in.	Impact Res Factor, lb-in.
Double-Strength Glass (⅛ in. thick)	6.685	3	20.06
		5.75	28.44
		4	26.74
		2	13.77
Wire-Reinforced Glass (¼ in. thick)	6.685	16	106.96
		23	153.76
		12	80.22
Laminated Glass (¼ in. thick)	6.685	18	120.33
		12	80.22
Plate Glass (¼ in. thick)	6.685	14	93.6
		19	127.0
		20	133.7
Tempered Glass (¼ in. thick)	6.685	116	775.4
		84	561.5
		96	641.7
Acrylic Sheet Plastic (¼ in. thick)	6.685	148	989.38
		168	1123.08
		152	1016.12
		182	1216.67
	8.975	134	1202.65
Allyl Ester Sheet Plastic (¼ in. thick)	6.685	96	641.76
		70	467.95

a series of tests in which double-strength, wire-reinforced plate and tempered glasses, and acrylic and allyl ester plastics glazing materials were studied.

The tests show that next to acrylic the strongest material was tempered glass which had slightly more than half the impact strength of the acrylic plastic. Third strongest was allyl ester plastic whose failure point was about 5% under that of tempered glass. Wire-reinforced glass, plate glass and laminated glass were all practically equal, with impact resistance about 1/10 that of the acrylic glazing. The lowest values were obtained for double-strength glass. Detailed test data are given in an accompanying table.

How glazing was tested

Test specimens consisted of 18 x 24-in. panes mounted in a large wooden frame to simulate a window installed in a door. The frame was placed on a concrete floor and rested



WELDED TUBING *offers*

- **THE SIZE**
- **THE GRADE**
- **THE SHAPE**

For a versatile tubular product, nothing equals Welded Steel Tubing. The quality producers offer a broad range of sizes and wall thicknesses in all weldable grades of carbon, stainless steel and other alloys. It is particularly adapted to shapes ranging from round, square and rectangular to the most complex special cross sections.

Welded Steel Tubing—as manufactured by the quality tube producers—offers a concise answer to most design problems. Specify Welded Tubing on your next order.

GENERALLY AVAILABLE ROUND SIZES* (B. W. G.)

Size of Tubes	CARBON		STAINLESS
	Cold Rolled	Hot Rolled	
⅛			20-25
¼			16-25
⅜	14-22		16-25
½	14-22		14-25
⅝	13-22		14-25
¾	13-22	13-16	12-25
⅞	13-22	13-16	12-25
1	11-22	11-16	11-25
1⅛	11-22	11-16	11-25
1¼	11-22	11-16	11-25
1⅜	11-22	11-16	10-23
1½	11-20	10-16	10-23
1⅝	11-20	8-16	10-23
1¾	11-20	8-16	10-23
1⅞	11-20	7-16	10-23
2	11-20	6-16	9-23
2⅛	11-20	6-16	9-22
2¼	11-20	5-16	9-22
2⅜	11-18	5-16	8-22
2½	11-18	4-16	8-22
2⅝	11-18	4-16	8-21
2¾	11-18	4-16	8-21
2⅞	11-18	4-16	8-20
3	11-18	4-16	8-20
3⅛	11-18	3-16	8-20
3¼	11-18	3-16	8-20
3⅜	11-18	3-16	8-20
3½	11-18	3-16	8-20
3⅝	11-18	3-16	8-20
3¾	11-18	3-16	8-20
3⅞	11-18	3-16	8-20
4	11-18	3-16	8-20
4½	11-16	3-16	8-18
4¼	11-16	3-16	8-16
4⅜	11-16	3-16	8-16
4½	11-16	3-16	8-20
4⅝	11-16	3-16	8-18
4¾	11-16	3-16	8-18
4⅞	11-16	3-16	8-18
5	11-16	3-16	8-18
5½	11-16	3-16	—
6	11-16	3-16	9-20

*Intermediate sizes, also larger and smaller sizes and heavier walls are available. Square, rectangular and other tubing shapes are also available in peripheries from 1" to 20" inc.

CARBON GRADES

Grade Designation	Carbon %	Manganese %	Phosphorus % Max.	Sulphur % Max.
MT 1010	0.05/0.15	0.30/0.60	0.040	0.050
MT 1015	0.10/0.20	0.30/0.60	0.040	0.050
MT X1015	0.10/0.20	0.60/0.90	0.040	0.050
MT 1020	0.15/0.25	0.30/0.60	0.040	0.050
MT X1020	0.15/0.25	0.70/1.00	0.040	0.050

HIGH CARBON GRADES

Grade Designation	Carbon %	Manganese %	Phosphorus % Max.	Sulphur % Max.
C 1025	0.21/0.28	0.30/0.60	0.040	0.050
C 1026	0.21/0.28	0.60/0.90	0.040	0.050
C 1030	0.27/0.35	0.60/0.90	0.040	0.050
C 1035	0.31/0.39	0.60/0.90	0.040	0.050

STAINLESS STEEL PIPE SIZES

Stainless Steel Pipe Sizes are available from ⅛" I.P.S. through 2" I.P.S. in A.S.A. schedule 40S; from ⅛" I.P.S. through 4" I.P.S. in schedule 10S; and from ⅛" I.P.S. through 4" I.P.S. in schedule 5S wall thicknesses. Inquiries for larger diameters should be referred to a quality stainless steel pipe producer listed below.

STAINLESS GRADES

Type No.	Carbon (*)	Chromium	Nickel	Other Elements
302	.15	17-19	8-10	....
304	.08	18-20	8-12	....
304L	.03	18-20	8-12	....
309	.20	22-24	12-15	....
309S	.08	22-24	12-15	....
309SCB	.08	22-24	12-15	cb10XC Minimum—1 Maximum
310	.25	24-26	19-22	....
310S	.08	24-26	19-22	....
316	.08	16-18	10-14	Mo. 2-3
316L	.03	16-18	10-14	Mo. 2-3
317	.08	18-20	11-15	Mo. 3-4
321	.08	17-19	9-12	Ti 5 X C Minimum
329	.20	23-28	2½-5	Mo. 1-2
330	.15	14-16	33-36	....
347	.08	17-19	9-13	Cb-Ta 10 X C Minimum
348	.08	17-19	9-13	Cb-Ta 10 X C Minimum Ta .10 Maximum
430	.12	14-18	....	....
442	.20	18-23	....	....
443	.20	18-23	....	Cu .9-1.25

(*) Maximum—unless otherwise indicated.

LC-592

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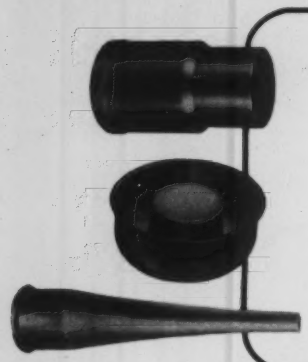

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⅛" stainless machined to ±.005.

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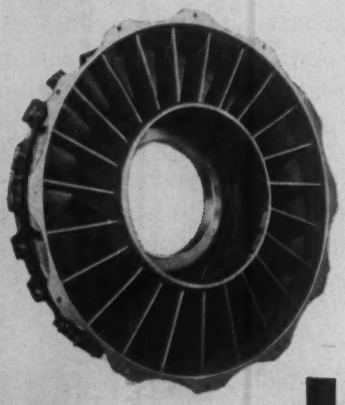

Typical Stalker fabrication. Nozzle assembly of nimonic alloy. (Photo courtesy of Continental Aviation and Engineering Corp.)

Whatever your problem may be, our engineering, development and production facilities are at your disposal. Write, wire or phone for information.

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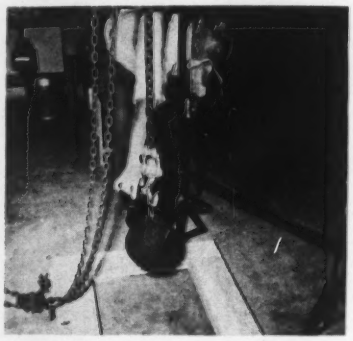

***Weighted ball** dropped from various heights was used to evaluate glass and plastic safety glazing.*

on a layer of foam rubber to insure even distribution of impact.

Impact was delivered by a felt-covered, weighted ball which was permitted to drop by free fall onto the test pane. Two different ball weights (6.685 and 8.975 lb) were used depending on the test material, though both balls had the same 7½-in. dia. The weight of the ball multiplied by the height of the fall necessary to break the test pane gave a numerical result for comparing the impact resistance of the various materials.

The tests were performed at Dow Chemical Co.'s Rocky Flats plant in Denver, Colo.

Low Alloy Steels for Nuclear Reactors

A series of low manganese steels for nuclear reactors has been introduced by Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30. The steels are said to have a chemistry considered to be a radical departure from that of standard steels, i.e., manganese and cobalt contents are extremely low. Other elements such as titanium are added, when needed, to provide the best combination of nuclear and mechanical properties. The steels are said to have excellent cold forming characteristics.

als, unlike other steels, do not retain radioactivity when used in nuclear

The specially formulated materi-reactors. Thus, nuclear reactor parts

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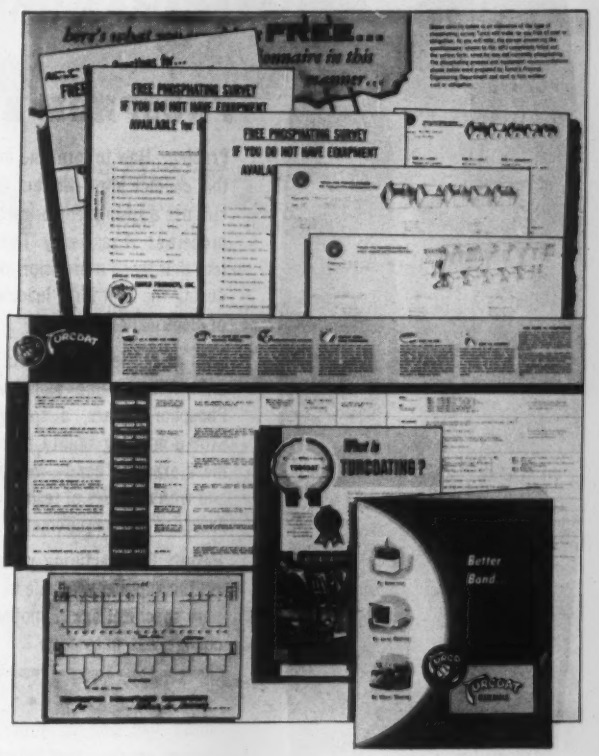
Whether or not you are currently Phosphating, you owe it to yourself to send today for your free Turco Phosphating Analysis Kit!



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Turcoat processes currently in use range from small, inexpensive 3-tank set-ups all the way to elaborate 11-stage spray washing systems. With Turcoat, paint is anchored uniformly... permanently. Should accidental gouging occur, there is no corrosion "creep back" under the paint. Turcoat processes slash number of rejects and other problems involved in improper preparation, minimize packing and crating costs, establish and assure customer preference.

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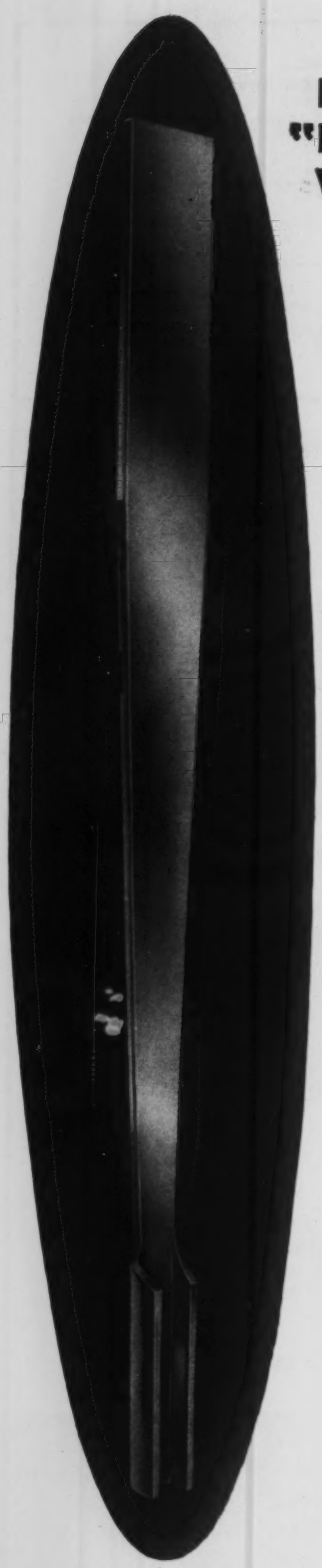

Approximately 1¾ actual size

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. . . with miller

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PHOSPHOR BRONZE

Problem: How to form the intricate bend in this contact arm—without fracturing—and still use a spring temper material with good properties of resiliency. This was the problem that faced a precision stamper* in producing the arm for a leading manufacturer of electrical equipment.

Each alloy tried was subject to fracture . . . until Miller came along with 200-PLUS Phosphor Bronze, a spring temper alloy with a forming ability that permitted the most exacting bend—without fracturing—and with qualities of resiliency that actually exceeded the requirements of the job.

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*Name and case history on request

• • •

Sound like one of your problems? The chances are good that Miller specialists can help you solve it—with either a standard alloy or one specially tailored to your requirements. Contact your Miller man.

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ROLLING MILL DIVISION

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. . . WHERE PHOSPHOR BRONZE IS THE MAIN LINE—NOT A SIDELINE

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Hot formed tube *measuring 2⅜ in. o.d. (left) was readily reduced to ¾-in. o.d. tubing (right) by cold drawing techniques.*

made of the steels are readily accessible to personnel for making repairs or adjustments. (For information on the selection of materials for easy maintenance in nuclear power plants, see M/DE, Jan '59, p 73.) In addition to nuclear applications the steels can be used for aircraft, missile and electronic parts.

J&L's nuclear steels can be produced in the form of plate, sheet, strip, bars, tubing, rods, wire and extruded shapes, and can be welded and fabricated by conventional methods.

Five Phenolic Plastics

Five new phenolic molding compounds were introduced recently by Loven Chemical of Calif., Newhall (L. A. County), Calif. The materials are called Alcylite.

PG-001 is an improved, fast curing, general purpose phenolic molding compound suitable for compression or transfer molding. Molded parts withstand temperatures up to 300 F and have a tensile strength of 7000 psi, a compressive strength of 30,000 psi, and a notched Izod impact strength of 0.28 ft-lb per in.

PH-001 is a glass-reinforced phenolic molding compound with good molding properties. Molded parts withstand temperatures up to 500 F and have a tensile strength of 6000 psi, a compressive strength of 25,000 psi, and a notched Izod impact strength of 2.0 ft-lb per in. Molded parts have fair flame resistance and a water absorption of 0.35%.

PM-002 is a two-step, nylon flock-

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DAPON resin molded parts exhibit outstanding stability under extreme conditions of exposure to heat and humidity. Under such conditions they do not crack or change shape. For example, after several months exposure to boiling water, DAPON resin molded cups show no degradation of any kind. DAPON resin molded parts are serviceable at temperatures up to 400-450°F. Higher temperature modifications of DAPON resins are currently under development.

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DAPON resin exhibits almost no shrinkage during cure and no shrinkage following cure. The lack of post-mold shrinkage makes possible formation of complex matching parts with close tolerances and small or large metallic inserts without cracking.

Chemical Stability

DAPON resin compounds are extremely resistant to acids, bases and organic solvents even at high temperatures, as well as to staining and color degradation.

Electrical Stability

DAPON resin molded parts are noted for the retention of their excellent insulation resistance, dielectric strength, and arc resistance even after exposure to high humidity and to elevated temperatures. DAPON resin's unusual chemical stability insures absence of breakdown and attendant corrosion of metallic electronic components under the most severe conditions of use. DAPON resin is unmatched by any other plastic in this regard.

Color Stability

DAPON resin can be compounded in pastel colors which exhibit greater color stability at elevated temperature than any other known colored plastics.

For Help In Solving Your Problems

Write today for technical literature detailing properties, uses and methods of application for DAPON resin.

*DAPON Resin is Food Machinery and Chemical Corporation's registered trade name for its brand of diallyl phthalate prepolymer. Names of compounders of DAPON resin molding powders are available on request.

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....	How to Select and Specify Glass	....	Sleeve Bearing Materials
....	Nickel Silvers	....	Sheet Formed Plastics Parts
....	Hard Coatings and Surfaces	....	How to Select a Stainless Steel
....	Selecting Plastics Laminates	....	Engineer's Guide to Plastics
....	Hot Forged Parts	....	Organic Coatings for Metal Products

....Guide to Materials Standards & Specifications—PRICE 75¢

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filled phenolic molding powder with good electrical properties. The compound has a heat distortion point of 250 F. Molded parts have a tensile strength of 7500 psi, a compressive strength of 26,000 psi, a flexural strength of 10,500 psi, and a notched Izod impact strength of 0.65 ft-lb per in.

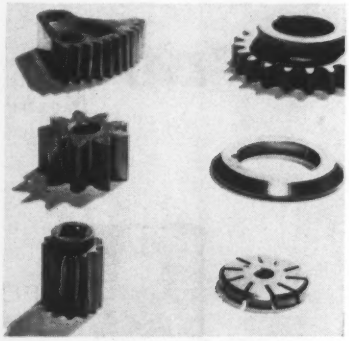
PS-002 is a flame resistant, high impact phenolic molding compound: the flame retardant is noncorrosive. The compound has a heat distortion temperature of 310 F. Molded parts have a tensile strength of 6000 psi, a compressive strength of 25,000 psi, a flexural strength of 12,000 psi, and a notched Izod impact strength of 2.0 ft-lb per in.

PM-003 is a sisal-filled high impact phenolic molding compound that can be molded on standard equipment. The material is expected to find use as pulleys, meter housings and automotive parts. Molded parts have a tensile strength of 7000 psi, a compressive strength of 25,000 psi, a flexural strength of 11,000 psi, and a notched Izod impact strength of 1.4 ft-lb per in.

Alloy Iron Powder Has High Strength

A high strength, hydrogen-reduced iron powder containing small amounts of nickel and molybdenum has been developed. The powder has a minimum tensile strength of 60,000 psi when sintered, and 100,000 psi when heat treated.

Designated Type 6460, the iron powder is now available in produc-



***Typical parts** that can be made from a new low alloy iron powder.*

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...and you have an idea that *one special* extruded aluminum shape can be used instead of *several standard* rolled sections of another metal, saving many manufacturing steps and money. The idea needs exploring . . . the opinion of experts. But, the budget for research of this type is slightly battered. The matter is no longer a problem, for G.E.I.'s highly skilled staff is eager and ready to discuss your idea with you, *at no obligation*, on one part or a million. G.E.I. engineers specialize in adapting extruded aluminum to new functional roles . . . and they can soon tell you whether your idea is fact or fancy.

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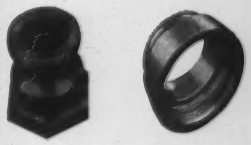
Machined Parts



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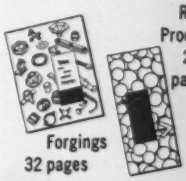

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Bellefonte, Pa. Newark, Calif.
QUALITY ALLOYS BY METAL SPECIALISTS

THE HIGHEST TEMPERATURE METALS

Available From FANSTEEL

Material	Melting Point	Density
Tungsten	6152°F	.697 lbs./cu. in.
Tantaloy (Tantalum alloy)	5475°F	.608 lbs./cu. in.
Tantalum	5425°F	.600 lbs./cu. in.
BL2 (Tungsten Alloy)	5250°F	.668 lbs./cu. in.
Molybdenum	4752°F	.368 lbs./cu. in.
Columbium	4379°F	.310 lbs./cu. in.

For more information on tantalum, tungsten and other Fansteel metals write to the Metals & Fabrication Division.

FANSTEEL

FANSTEEL METALLURGICAL CORPORATION North Chicago, Ill., U.S.A.

For more information, turn to Reader Service card, circle No. 465

tion lot quantities from Republic Steel Corp., Metal Powder Div., Toledo 5, Ohio. The iron powder is expected to find use in automotive, hardware and appliance parts.

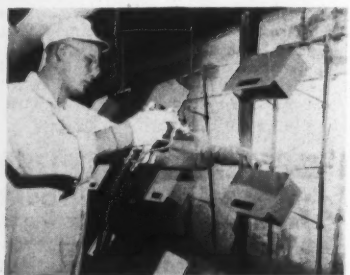
Republic gives the following characteristics for the low alloy iron powder:

1. It is soft and is easy to briquet.
2. High green strength.
3. Shrinkage values less than 0.004 in. per in. at densities above 0.23 lb per cu in., either sintered or heat treated.
4. Elongation of 6 to 8% "as sintered" after annealing and re-pressing, with 75,000 psi tensile strength.
5. Heat treated tensile strength of 180,000 to 190,000 psi after annealing, re-pressing and sintering; elongation at this strength level is 1.5%.
6. It develops high strength with short sintering times and conventional sintering temperatures.

Textured Coating Applied by Spraying

An improved textured vinyl coating material has been developed that can be applied by spray techniques. Formerly, the material, called Armorhide, could only be applied by laminating. The sprayable material was developed by J. L. Armitage & Co., 245 Thomas St., Newark, N. J.

A sprayed Armorhide coating has a pebbly, leather-like surface that is resistant to coffee stains, perspiration, scratching, abrasion and corrosion. Coated parts with minor dents can be hammered out without refinishing, according to the producer. Armorhide sprayed vinyl



Union Carbide Plastics Co.

***Applying** a textured vinyl coating by spray techniques.*

no need to design new RUBBER molds and dies!

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A 40 year accumulation of molds and dies are now on hand at Atlantic India, ready to serve you. Chances are one of our standing molds or dies will fit your needs.

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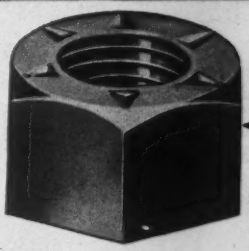
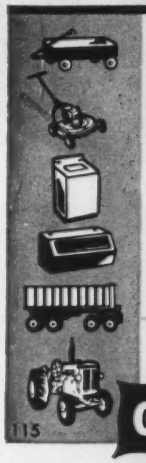
SPECIFY **GRIPCO LOCK NUTS**



to resist stress, wear and vibration

They increase product durability at low initial cost



Simple one piece design — no inserts — no outside devices. Nothing complicated — the Gripco locking action is within the nut itself, yet you get low initial cost and low application cost with increased customer satisfaction. Speed production and lower manufacturing costs on your products now.

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Gripco Products Include:

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all with or without the famous Gripco positive locking feature. Also Standard Semi-Finish Nuts.

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by American Latex are destined to change the manufacturing habits of the nation

STAFOAM, the miraculous "foamed in place" rigid or flexible polyurethane by American Latex Products Corporation, is applicable for an infinite variety of manufactured items. Proven to possess the required characteristics of lightweight, superior strength, smooth surfacing, temperature resistance and ease of application, STAFOAM is destined to change our material world. Its present use in American Industry alone confirms that destiny.

The new Freedlander Research and Development Center at Hawthorne, Calif., devoted entirely to the development of STAFOAM *applications, invites you to call or write for research and/or manufacturing information.*

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stafoam

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coatings bake to a hard finish in 20 min.

The sprayable coating material is presently being applied to computers, electronic accounting machines, tabulators, card punches, sorters and other data processing equipment in a variety of colors.

Extruded Rod, Tubing Made from Columbium

Commercial production of extruded rod and tubing made from columbium has been announced by Wolverine Tube, Div. of Calumet & Hecla, Inc., 17200 Southfield Rd., Allen Park, Mich. The company expects the extrusions to be used in nuclear power plants, rockets and missiles.

Wolverine Tube is accepting orders for columbium rod and tubing in the following dimensions: rod, ¼-1 in. dia; tube, 1 in. o.d., 0.020-0.085 in. wall thickness. Both rod and tube are supplied in lengths up to 20 ft. The producer says other sizes can be extruded for special orders.

Fiberglass Sleeving Is Tough, Elastic

A silicone rubber-coated fiberglass insulating sleeving withstands abuse during assembly without rupture of the dielectric film.

Because of its elasticity, the insulating sleeving can be expanded as much as four times its original size to cover knobs, terminals and irregular shapes. One size of the sleeving can do the job formerly done by three different sleevings, according to the developer.

The material, called Ben-Har 1151, is a product of Bentley, Harris Mfg. Co., Conshohocken, Pa. It will probably find use in such electrical parts as motors, generators, transformers, relays and solenoids. The sleeving, made by a new manufacturing process, is said to have better physical and electrical properties at temperatures up to 480 F than currently used sleevings.

The company expects to offer silicone rubber-coated sleevings in sizes

Assignments on the frontiers of present-day ceramic technology

CERAMISTS

BS, MS, PhD

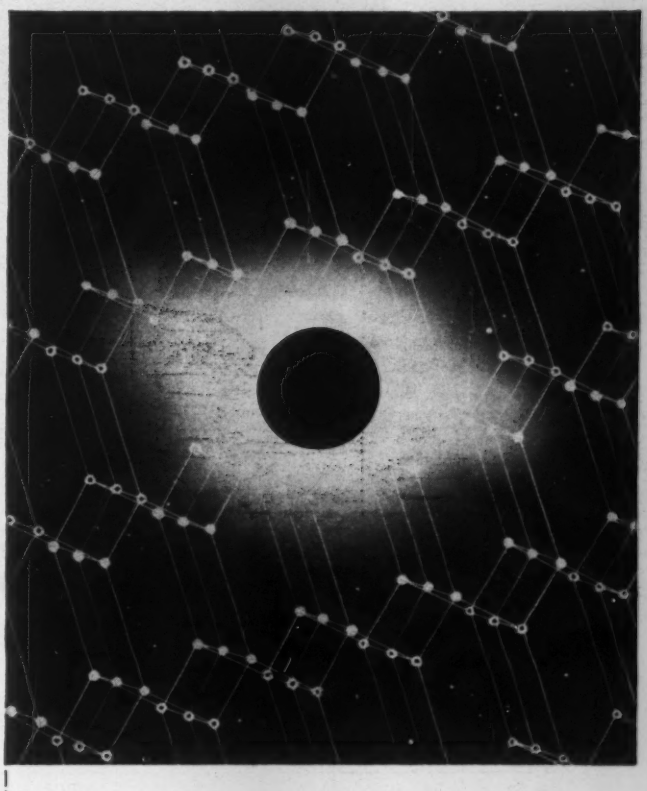
Development of Ultra-Refractories for Prolonged Service at 2000° F to 5000° F in Nuclear Flight Program

Ceramic problems facing engineers and scientists at General Electric's Aircraft Nuclear Propulsion Department equal—and transcend—the materials requirements created by missile re-entry conditions.

Consider this contrast: a nose cone plunging to earth at 15,000 mph reaches extreme temperatures for less than one minute... but ceramic components envisaged for nuclear flight will encounter operating cycles in the 2000°F to 5000°F range for periods of hours or days.

Current opportunities for ceramists include both applied research and materials development:

- **LEAD TECHNICAL DIRECTION** of major materials development activity utilizing ceramics. PhD.
- **SUPERVISE APPLIED CERAMIC RESEARCH** including fabrication processes, testing, development of novel ceramic materials. PhD.
- **CONDUCT RESEARCH** in ceramic technology in particular fields of fabrication, chemical reactivity, high temperature testing, development of high strength ceramic materials. MS, BS.
- **TAKE PROGRAM PLANNING RESPONSIBILITY** ...including financial estimates... for major ceramic materials development activity. PhD, MS, BS.
- **PROVIDE** entire Applied Materials Research operation with scientific consulting advice in the fields of ceramics and physical chemistry related to aircraft nuclear propulsion. (Heavy experience plus graduate study essential.)



CERAMISTS who value the opportunity to do original work with a company that fosters free inquiry and initiative, are invited to inquire about positions now open in the areas to the left. Please include salary requirements with resume.

Write to Mr. P. W. Christos, Div. 41-MC

AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

GENERAL ELECTRIC

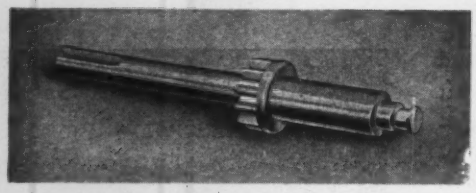
P.O. Box 132 Cincinnati 15, Ohio

For more information, turn to Reader Service card, circle No. 471

here's PROOF of how the GRC method cuts the cost of small parts...

Shown actual size

Take, for example, this part which previously had been produced 3 different ways...



METHOD A
ASSEMBLY OF 2 SCREW MACHINE PARTS
Screw Machine Part
Mill Slot
Machined Extrusion
Assembly
4 Production Steps
+ 3 inspections

METHOD B
CONVENTIONAL DIE CAST AND MACHINED PART
As Cast
Trimmed
Machining for Undercut and Sizing of Diameters
3 Production Steps
+ 2 inspections

the GRC method
AUTOMATICALLY DIE CAST
1 Production Step
—only one inspection

Now take a look at these comparative figures . . .

	Purchased Material	Cost/M	Scrap Generation	Cost in lots of 100 M	500 M
Method A	Brass	$30	30%	$70/M	$69/M
Method B	Zinc Alloy	$3.82	5%	$30/M	$28/M
GRC Method	Zinc Alloy	$3.64	None	$15/M	$11.50/M

Check the chart; you'll see clear proof of how GRC's DIE CASTING METHOD offers substantial savings on your small parts. The Gries Method delivers parts of high uniformity, with close tolerances . . . ready for use. Assembly and most other secondary operations are eliminated.

"Write, wire, phone NOW for GRC's bulletin "Small Die Castings Exclusively"; send prints for quotation.

World's Foremost Producer of Small Die Castings

MAXIMUM SIZES: 1¾" ½ oz. No Minimum

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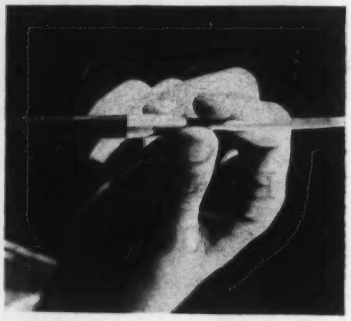
What's new IN MATERIALS



***Expandable sleeving** is available in a wide variety of colors.*

up to 2 in. i.d. Formerly, sleevings were available only in sizes up to ⅝ in. i.d. The large sleevings are expected to find use in big motors and generators, as well as in wire harnesses and aircraft ducting.

Ni-Cr-B Brazed Joints Withstand 2200 F

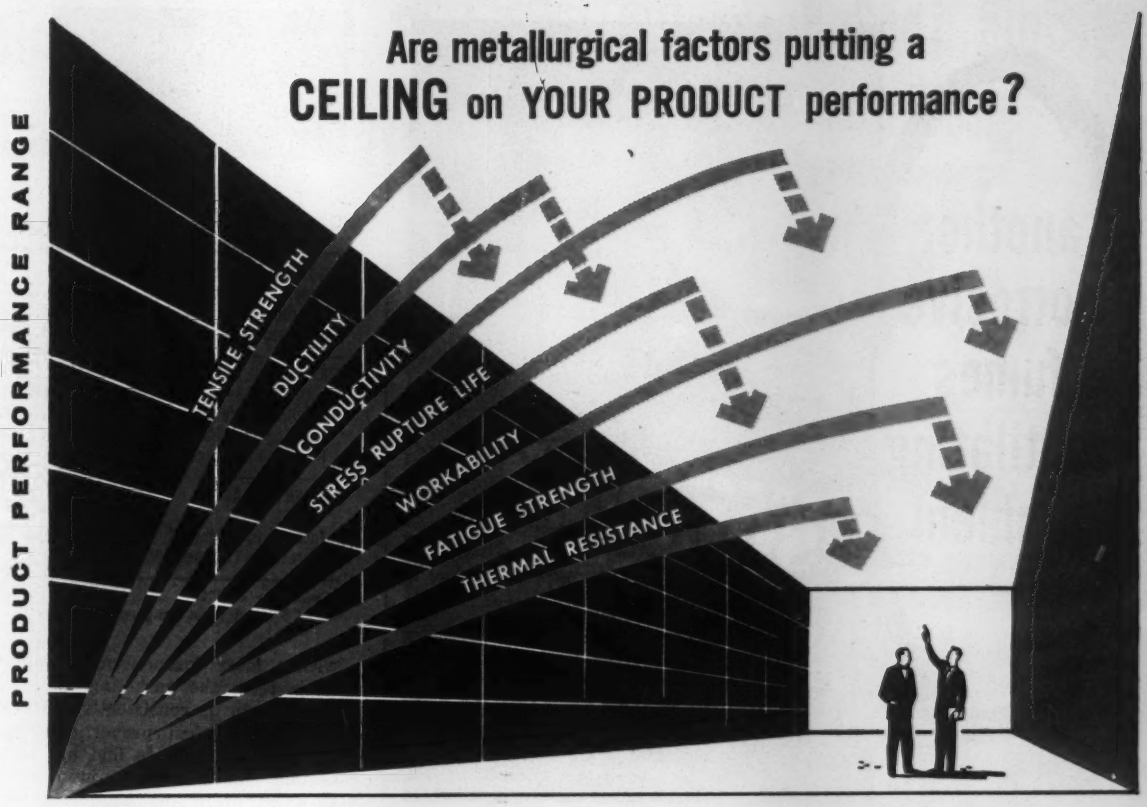
A new nickel-chromium-boron brazing alloy produces high strength joints for continuous service at temperatures up to 2200 F. Called Nicrobraz No. 170, the material is available from Wall Colmonoy Corp., Stainless Processing Div., 19345 John R St., Detroit 3.

According to the producer, Nicrobraz 170 will satisfactorily braze tungsten and molybdenum bearing alloys. It provides good ductility in the resulting brazed joint, produces small fillets for neat appearance, and has good wetting characteristics. Recommended brazing temperature for the alloy is 2150 to 2200 F in pure dry hydrogen.

The brazing alloy is supplied as a powder and is best applied as a mixture with cement.

Gasketing Material

An oil and solvent resistant rubber-asbestos gasketing material has been introduced by F. D. Farnum Co., 4940 W. Flournoy St., Chicago 44. Called Kaobestos, the gasketing is made by a process in which asbestos fibers are individually coated



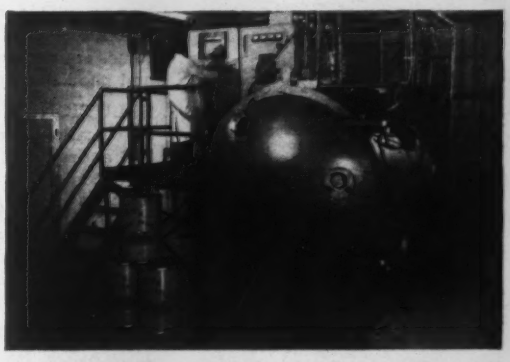
You can lift that ceiling

with Cannon-Muskegon vacuum-melted alloys

If shortcomings in metals are restricting your product development . . . LOOK TO VACUUM MELTING.

Vacuum melting has proven its superiority in providing alloys of extraordinary cleanliness — free from harmful inclusions and gases. Vacuum melting will produce alloys with improved fatigue life and thermal resistance, greater strength and ductility, better corrosion and abrasion resistance, higher electrical properties . . . alloys that are tougher, longer lasting . . . with the desirable characteristics to make new and better products.

Production or development . . . Cannon-Muskegon can exactly meet your requirements. Our metallurgists can analyze your problems and accurately determine how vacuum melting will serve you best.



UltraMet COBALT — FERROUS — NON-FERROUS — AND NICKEL-BASE ALLOYS are poured at pressures from 1 to 10 microns in this vacuum-melting furnace at Cannon-Muskegon.

***UltraMet ALLOYS** are available in a wide variety of cast or wrought forms. Billets or ingots. Bars — round, square or hex. Strips. Sheets. Wire. Experimental castings. For additional information, write for UltraMet Bulletin.*

ULTRAMET
VACUUM-MELTED ALLOYS
FOR INDUSTRY

CANNON-MUSKEGON CORPORATION
2873 Lincoln Avenue • Muskegon, Michigan

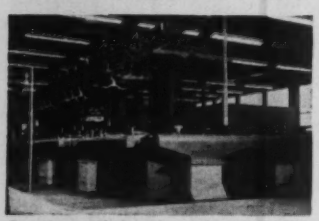
METALLURGICAL SPECIALISTS

For more information, turn to Reader Service card, circle No. 496

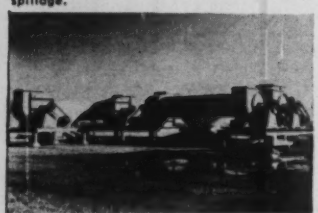
another corrosive fumes ventilating problem

Duracor Ventilation System exhausts 250,000 C.F.M. of corrosive fumes from large electronic equipment plant.

Strong, lightweight DURACOR ducts over 5 feet in diameter require minimum support.



Corrosion-proof throughout, these DURACOR "drops" need no exterior protection from spillage.



Weather and corrosion resistance are provided by DURACOR "T" sections on roof.

PROBLEM: This ventilating system had to withstand sulphuric, nitric, chromic, phosphoric acid and cyanide fumes emitted from the plant's plating and anodizing operation.

SOLUTION: Working from customer specifications, Ceilcote engineers built the entire ventilating system shown here completely from DURACOR.

INSTALLATION: Experienced Ceilcote supervisors and crews handled the complete installation under one contract. Materials and workmanship are fully guaranteed.

WHAT'S YOUR PROBLEM? . . . DURACOR resists any corrosive gas, fume or liquid . . . can be fabricated to virtually any shape. Write today and tell us about your requirements.

DURACOR CEILCOTE 8019-CC

THE CEILCOTE COMPANY, INC.
4899 Ridge Road • Cleveland 9, Ohio

For more information, turn to Reader Service card, circle No. 450

What's new IN MATERIALS

PROPERTIES OF KAOBESTOS

ORIGINAL PHYSICAL PROPERTIES	
Tensile Strength, psi	2000
Compressibility under Load (5000 psi), %	12
Min Recovery after Compression, %	40
PROPERTIES AFTER AGING IN ASTM OIL NO. 3[a]	
Loss in Tensile Strength, %	30
Max Compressibility, %	20
Increase in Thickness, %	6
PROPERTIES AFTER AGING IN ASTM FUEL B[b]	
Increase in Weight, %	20
Increase in Thickness, %	7

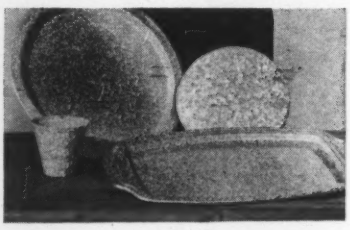
[a]Aged 5 hr at 300 F.
[b]Aged 5 hr at room temperature.

with a latex formulation. Products made from the gasketing material are said to be consistently uniform in their physical properties. Kaobestos is expected to find use as a sealing material in automobiles, chemical processing equipment, refrigerators and refining equipment.

Spangled Aluminum for Decorative Uses

Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19 has announced the commercial availability of Spangle Sheet, a new aluminum product for decorative applications. The material is expected to find use as automotive trim, giftware, refrigerator and appliance trim, lighting fixtures, jewelry, novelty items and interior decorations.

To produce Spangle Sheet, unusually large grains are induced in aluminum alloy sheet. Subsequent acid etching causes individual grains to stand out in relief; the action of the etch also develops mirrorlike



***Products** such as these can be formed of spangled aluminum sheet.*

How the Armco Stainless "Wardrobe" of Finishes Can Help You Save

No matter how they are finished on the outside, Armco Stainless Steels are always the same high-quality, corrosion-resisting steels all the way through. But you can save money by specifying the *one finish* from the Armco Stainless "wardrobe" that best suits your product's needs and requires the fewest additional finishing operations in your plant.

MANY ARMCO FINISHES TO CHOOSE FROM

Because they serve in many different products, Armco Stainless Steels are available in a wide variety of surface finishes.

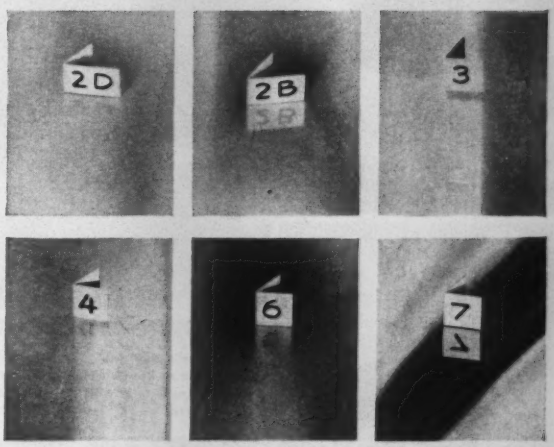
Tough jobs call for workclothes. One of the unpolished surface finishes is generally most economical in high-temperature industrial uses, involving highly oxidizing or very corrosive atmospheres. On the other hand, when appearance, sanitation, or easy cleaning comes first, a polished stainless surface is required.

Patented Armco processes offer additional possibilities. Small parts and intricately-shaped pieces can be economically polished by Armco's electropolishing process. Another Armco process "Ebonizes" (blackens) stainless steel parts.

BROAD RANGE OF STAINLESS

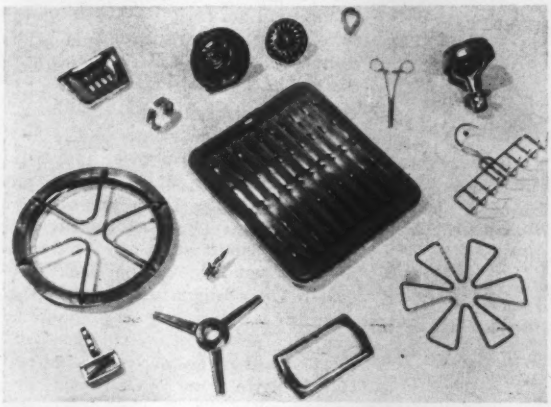
Remember, too, Armco Stainless Steels are available in a wide range of standard and special grades—in gages, sizes, and shapes to suit design needs. For more information about Armco's Stainless Steels or their surface finishes, just fill in and mail the coupon or call your nearest Armco Sales Office.

New steels are born at Armco



Pictured are six of the eight mill finishes available on Armco Stainless Steels. No. 2B and No. 2D Sheet Finishes correspond to No. 1 and No. 2 Strip Finishes, respectively. Not shown are the hot-rolled, annealed and pickled No. 1 Sheet Finish for industrial products and the new Armco SOFTONE Finish for Type 430 Stainless Steel strip. SOFTONE was developed to provide a soft, lustrous surface, yet avoid mirror-like reflectivity.

Small or intricately-shaped stainless pieces like these can be economically polished by the Armco Electropolishing Process.



ARMCO STEEL CORPORATION, 1569 Curtis St., Middletown, Ohio
I would like more information about:
☐ Armco Stainless Steels
☐ These Armco Stainless finishes_____,_____,
_____,_____
NAME_____
FIRM_____
STREET_____
CITY_____ ZONE____ STATE_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

For more information, turn to Reader Service card, circle No. 421

Ideas for missile engineers

Hackney components—deep drawn shapes, shells and parts—offer designers many advantages, including:

- great strength with minimum weight
- elimination of heavy castings, forgings, etc.
- maintenance of exact diameters, wall thicknesses
- simplification of assemblies to speed installations
- naturally smooth surfaces which are easy to paint, clean, maintain
- making parts in ten different metals
- maximum latitude in designing; for example, wall thicknesses .050" to .700"...working pressures to 6000 psi...as well as ample design latitude in capacities, diameters and depths

For engineering facts, data on components already produced by Hackney engineers for missile and rocket projects, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Hackney

DOWNINGTOWN IRON WORKS

For more information, turn to Reader Service card, circle No. 401

facets on each grain. Since each grain is positioned differently, a viewer observes varying degrees of light reflected from the surface of the sheet.

The new product is available in thicknesses ranging from 0.032 to 0.100 in. Maximum width of the sheet is 36 in. and maximum length is 96 in.

Two Plastics Resins Developed in Russia

Two new plastics materials have been developed in Russia that so far as is known are not commercially available in this country. The materials are: 1) a terpolymer consisting of methyl methacrylate, styrene and acrylonitrile designed for injection molding and claimed to have ". . . better light stability than either styrene or methacrylate"; and 2) a polyethylene resin made by a low pressure process that is claimed to have better tensile strength properties in the oriented state than polyethylene resins made by high pressure processes.

Information on the two new plastics resins was obtained from a report on the Soviet plastics industry issued recently by the Society of the Plastics Industry, Inc., 250 Park Ave., New York 17. Here is a brief summary of some other plastics discussed in the report.

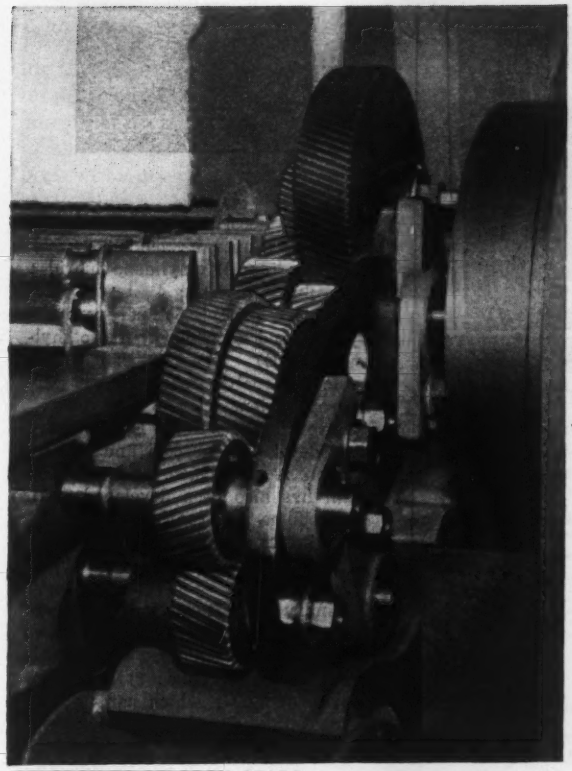
Styrene copolymers

A methylmethacrylate (60%) and styrene (40%) polymer has been developed that is said to have better light resistance than polymethylmethacrylate. (For information on a similar material recently developed in this country, see M/DE, Feb '59, p 124.) Light resistance of the styrene methacrylate copolymer is not as good as that of 100% methacrylate but is better than that of 100% polystyrene. Behind the development of this copolymer was the desire to obtain a relatively light resistant material which can be injection molded with the use of a plasticizer. The copolymer has good resistance to gasoline and is therefore applicable to automotive uses.

Fluorinated polymers

The Russians have been working on fluorinated polymers for the past

Put strength, long life, silence into gears and couplings with CDF Celoron® molded plastics



CELORON-TO-CELORON GEARS in drawing rolls made by Ideal Industries, Inc., Bessemer City, N. C. These are helical-cut gears—the toughest to machine, requiring the toughest material. Celoron is it. Other Celoron parts for this application are shown below, top right.

WORK MIRACLES IN MACHINERY with this amazing golden phenolic material! Celoron gears help eliminate noise and reduce wear on mating metal gears. Even the roughest-used helicals last . . . and last . . . and last.

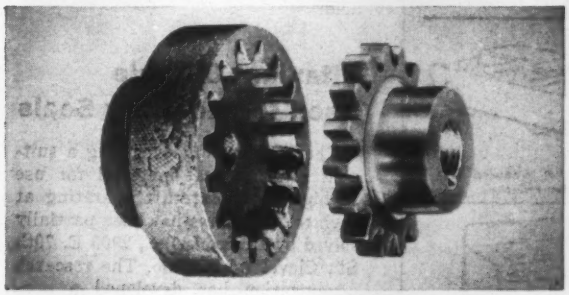
HIGH MECHANICAL STRENGTH. Typical Celoron strengths: tensile, 6,500 psi; flexural, 10,000 psi; compressive, 25,000 psi; shear, 8,500 psi. Dimensionally stable and readily machined, Celoron fills the bill where costly metal parts fail.

ELECTRICAL INSULATION VALUE. Celoron is a non-conductor with high electrical insulation value. It makes ideal mechanical-electrical parts. Celoron couplings effectively insulate motors from driven machinery.

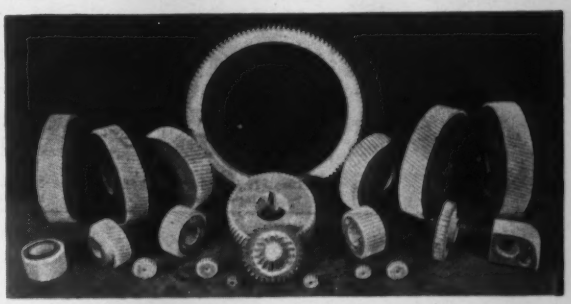
CDF FABRICATION SERVICE. Let the plastics-fabrication and molding experience of CDF save you time and money, and assure you delivery of production quantities of CDF plastics and molded parts—on time and as specified. The CDF man can help you from the very beginning. See his phone number in the Product Design File (Sweet's). Or send us your print or your problem, and we'll return samples and technical literature for your evaluation.

CONTINENTAL-DIAMOND FIBRE

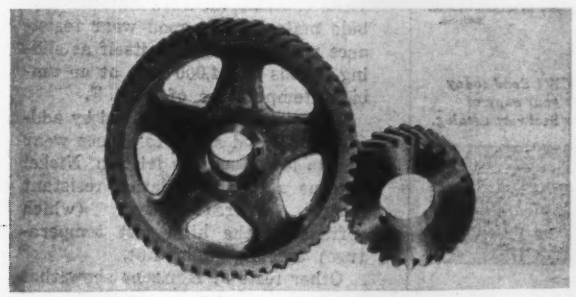
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 25, DEL.



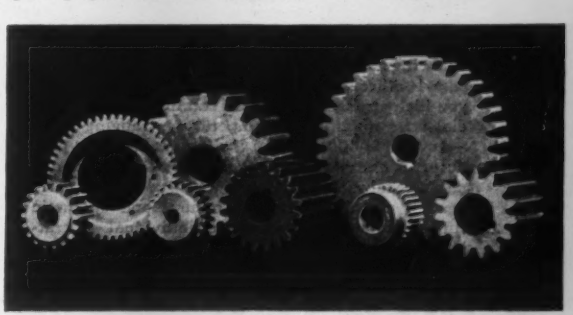
LOW-COST, EASILY-ASSEMBLED CDF Celoron flexible coupling transmits power smoothly, silently . . . insulates motor from machine . . . needs no lubrication . . . works vertically or horizontally.



PRECISELY MACHINED KEYWAYS help keep these Celoron parts silent and strong in the Ideal drawing rolls illustrated in top photograph. Note wide range of sizes and shapes.

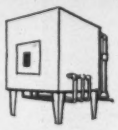
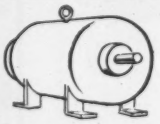


CELORON-TO-STEEL combination makes this long-wearing timing mechanism for gasoline engines. Celoron gear absorbs shock, cuts sound to a minimum, holds timing longer.



STRONG, SILENT CELORON makes both drive and driven gears. In fact, many machine applications are 100% Celoron geared for light weight, elimination of excess play, long life.

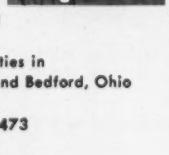
For more information, turn to Reader Service card, circle No. 439

PART	COULD BE	REALLY IS
	Chemical resistant tool for scraping bottom of the barrel.	 Silicone gasketing for high temperature industrial oven.
	Tip for page stick used by a faint-hearted fakir.	A chemical and temperature resistant bellows used in jet aircraft.
	Last word in wrapping for a red-hot mummy.	 Special Silicone winding for an electric motor.
	Disguise for a half-masked refrigerator-raider.	Silicone gasket produced for the automotive industry.
	All-weather decoy for duck hunters.	Heat-resistant Silicone extrusion used for oven gasket.

8301-SR

Guessing games can be fun . . . but not with rubber parts! Silicone rubber parts by Stalwart assure you high strength, maximum stability and superior dielectric qualities at temperatures ranging from −160° to +600° F. And Stalwart is the only producer of extruded and calendered *Silicone sponge parts.* Stalwart also accurately produces parts from a complete range of natural and synthetic rubber compounds to meet individual operating requirements. Write for complete information.

NEW! Send today for your copy of the Stalwart catalog.



STALWART RUBBER COMPANY

165 Northfield Road
Bedford, Ohio
Manufacturing facilities in
Jasper, Georgia and Bedford, Ohio

For more information, turn to Reader Service card, circle No. 473

10 years, according to the report. They have used as monomers: 1) vinyl fluoride; 2) vinylidene fluoride; 3) trifluoroethylene; 4) tetrafluoroethylene (TFE); 5) perfluoropropylene; and 6) chlorotrifluoroethylene (CFE). The Russians have made homopolymers of all but perfluoropropylene.

Several grades of TFE resin have been developed for cold and hot extrusion. A suspension grade of TFE resin has also been developed from which films and coatings are made. (For information on a similar U. S. material, see M/DE, Jan '59, p 115.)

Binary and ternary copolymers have been made of all of the above mentioned monomers. From this work scientists found: 1) an elastomeric copolymer which can be used in gaskets at 660 F; and 2) a copolymer (probably a ternary one) which contains C_2F_4 and is soluble in a mixture of ethyl acetate, ethyl alcohol and acetone. They have spun fibers from this latter solution, and have made fabrics from the fibers that are said to be resistant to nitric acid.

Titanium Carbide Used for Rotating Seals

The problem of developing a suitable rotating seal material for use in high speed aircraft operating at high temperatures has been partially solved by Horizons Inc., 2905 E. 79th St., Cleveland 4, Ohio. The research organization has developed a nonlubricated rotating seal made of a modified cemented titanium carbide material called Kentanium K162B. Tests show the modified titanium carbide material has good wear resistance when run against itself at sliding speeds of 14,000 fpm at an ambient temperature of 1100 F.

The material was modified by adding nickel and silver to reduce wear and to lower surface friction. Nickel acts as a tough, oxidation resistant matrix, whereas silver (which softens at the high test temperature) acts as a lubricant.

Other tests at Horizons show that an unimpregnated graphite seal coated with zirconium carbide has good wear resistance when run

New Plasmarc Torch Service for Production Parts from Refractory Metals—By harnessing the highest controlled temperatures ever used in industry—up to 30,000 degrees F.,—the new *Plasmarc* Torch makes possible the fast and accurate mass production of ultra-hard materials that have been virtually unworkable by any previous means.

With the patented *Plasmarc* Torch, LINDE is equipped to supply parts made of, or coated with refractory metals, or made of a variety of metals combined with non-metals or reinforced plastics. This method has been used successfully with pure tungsten, molybdenum, zirconium, and tantalum (all metals in the highest temperature range), hard carbide materials, and even precious metals, including platinum and palladium.

In powder or wire form, the metal being worked is fed into the torch chamber where a non-transferred electric arc generates temperatures above 15,000 degrees, literally melting the particles to a fluid or plastic state. Inert gases, flowing continuously, deposit them at near-sonic speeds on the workpiece. Jets of CO_2 cool the particles instantly to form heat-and-erosion-resistant material. Coatings, even on graphite, have an excellent bond. Shapes are built up on machined mandrels which are then etched away to leave the finished parts.

There are no known limitations on size or complexity of shape. Accuracy of ±.002 in. can be maintained. The *Plasmarc* Torch has been used to make high-density tungsten crucibles, special parts for nuclear work, sensitive electrical contacts, and electronic components and x-ray targets. LINDE will also provide a wind-tunnel materials testing service based on this device.

For information on this extension of LINDE's well-known Flame-Plating service, write Dept. N-3, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: LINDE COMPANY, Division of Union Carbide Canada Limited.

FOR MEN WITH IMAGINATION

Three-Level Ruby Maser—The Maser is a microwave amplifier utilizing energy stored in a molecular or atomic system. Emission of this energy is stimulated by the input signal. Masers operate at liquid helium temperatures and have incredibly low noise levels approaching zero db. Recently a University research laboratory* used LINDE single crystal synthetic ruby (Al_2O_3 with Cr_2O_3 additive) in a three-level solid state Maser. The ruby crystal was placed at the center of the Maser's tuned cavity and a magnetic field of 4200 gauss was applied. To bring electrons from a ground state into a permissible higher energy level, a pumping frequency of 24 kMc was used and the Maser successfully amplified signals at 9.3 kMc.

LINDE also supplies other crystals including rutile, spinel and sapphire (Al_2O_3). Sapphire is used in infrared optical systems, windows for high power microwave tubes, spacers and supports in vacuum tubes, radiation pipes. It has strength at elevated temperatures, melts at 2040°C, is hard, inert, non-porous and can be sealed to metals and glasses. Sapphire is currently available in the shape of domes, windows up to 4½ inches in diameter, rods and special configurations.

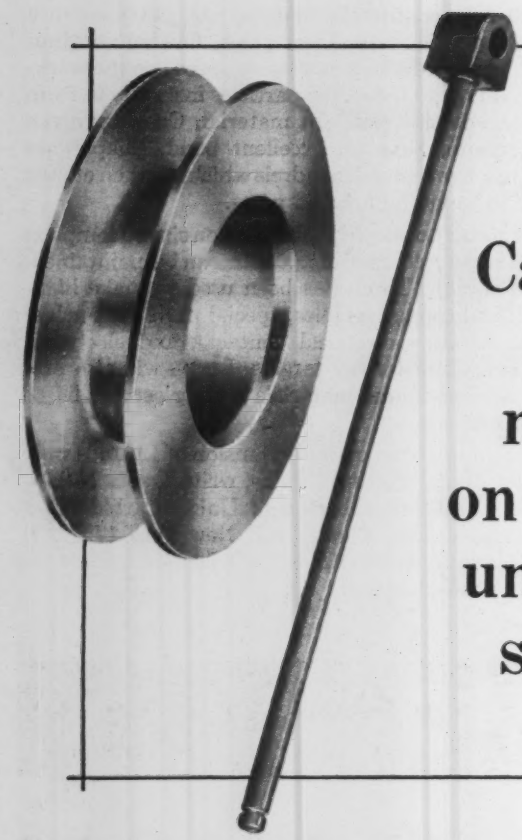
For further data write to Crystal Products Department N-3, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York.

*"Maser Action in Ruby," by G. Makhov, C. Kikuchi, J. Lambe, and R.W. Terhune. "Physical Review," Volume 109, Number 4, Page 1399, Feb. 15, 1958.

PRODUCTS WITH A FUTURE Linde TRADE-MARK UNION CARBIDE

The terms "Linde," "Union Carbide" and "Plasmarc" are trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 511



Die Casting saved money on these unusual shapes

Sometimes die casting wins by default. Take this spring retainer and spinning reel spool . . . neither, at first glance, seemed a job for die casting. But would it pay to stamp and braze and machine and drill the retainer? Would it be difficult to maintain a critical tolerance on the spool? Could you get necessary accuracy and strength?

In each case, other processes were previously used but die casting was later specified because it does so many things so well. That's the secret of die casting . . . *flexibility!* No other process combines strength, precision, speed and cost-cutting abilities quite like die casting.

If you want to know whether die casting can save you parts money, contact Twin City Die Castings. Twin City has a history of making the process save assembly steps—pay better.

...only DIE CASTING can
✓ cut your costs ✓ offer such flexibility
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For more information, turn to Reader Service card, circle No. 452

What's new IN MATERIALS

against type 303 stainless steel at sliding speeds of 14,000 fpm at an ambient temperature of 1050 F.

Other News . . .

Metals

▸ Stanford Research Institute scientists report that titanium metal will oxidize very rapidly under relatively mild conditions if a fresh metal surface is formed to initiate the reaction. Under static conditions, titanium will spontaneously ignite when in pure oxygen at pressures of 350 psi or more.

▸ Duraloy Co., Scottdale, Pa. is now supplying static, centrifugal and shell molded castings made of a new high nickel alloy called Duraloy HOM. Castings made of the alloy are said to keep their strength and to have good oxidation resistance at temperatures up to 2200 F.

▸ Zinc-coated sheets of a high strength, low alloy steel are now available from Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30. The product, marketed under the name JalZinc, is recommended for use as siding, flooring, angles, channels and guard rails. The sheets are available in gages from 10 to 20 and in widths from 22 to 48 in.

Nonmetallics

▸ A new epoxy resin, based on epichlorohydrin and novolac, has been developed by Dow Chemical Co., Midland, Mich. for high temperature applications. The experimental material, designated X-2638.3, has potential use in high strength adhesives for metal fabricating, glass-reinforced plastics for structural shapes, and electrical printed circuits.

▸ An impregnated cork-paper gasketing material withstands temperatures up to 300 F, has good resistance to gasoline and oil, and has low shrinkage in water. The material, known as Grade No. 218, is a product of Knowlton Bros., Inc., 215 Factory St., Watertown, N. Y. It is supplied in thicknesses from 0.025 to 0.060 in.

▸ A line of filled-TFE bearing materials in the form of finished and semifinished parts is now available from Chemical & Power Products, Inc., 11 Broadway, New York 4. The

CARBON AND ALLOY STEEL INVENTORIES...

They can and will—if you let *Frasse* stocks be your inventory! Your cost for steel ready for use will be less. You'll save the cost of labor, handling, processing and obsolescence...free plant space and idle capital for profitable use. You incur no expense until material is needed...then only the cost of steel—*not* the purchase price PLUS the *high cost of possession.*

With Frasse stocks as your inventory, you can pick from 20 different grades—any one of 2001 sizes. For, Frasse carries a complete range of carbon bars and shafting as well as commercial and aircraft quality alloys. There's always a size and grade for any application...*immediately available.*

Weigh the advantages of this modern solution to steel inventory problems. You get broad selection, fast deliveries—and the help of specialists that offer a wealth of technical information and problem-solving techniques. Place future orders for the carbon and alloy bars you need with Frasse—*your* Steel Service Center. You'll find it convenient...and far more economical than maintaining your own inventory.

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CARBON AND ALLOY STEEL SERVICE

Frasse Carbon and Alloy Stocks Include:

C1018	C1137	E9310
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B1112	C1213	4140
B1113	Ledloy	4142
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C1117	8620	E8740

4140 H.T. • 4142 H.T.

Precision Shafting • Special Finish
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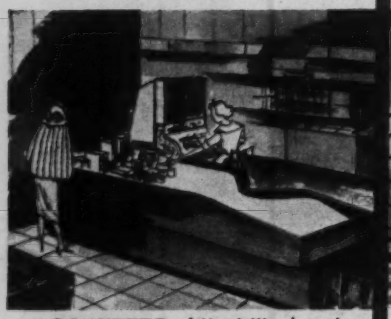
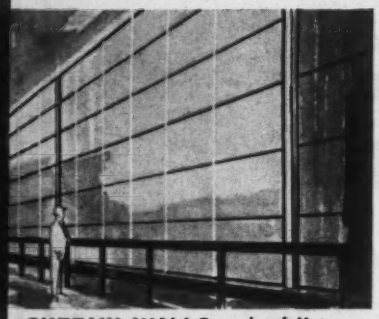
For more information, turn to Reader Service Card, circle No. 385

When wear creates problems...

MET-L-WOOD®
puts beauty to stay!



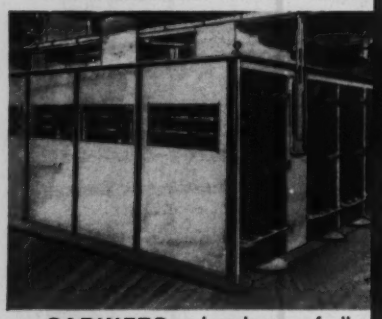
COUNTERS of Met-L-Wood can be designed to fit any decorating scheme, yet stand hardest service.



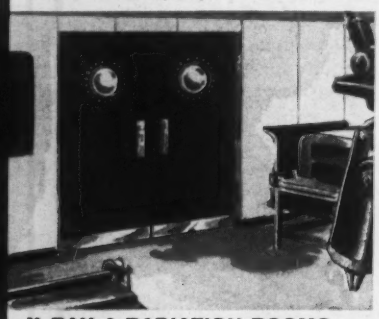
CURTAIN WALLS made of Met-L-Wood panels permit fast construction; lend beauty and life to buildings.

MOTOR STAIRWAY and **WALKWAY PANELS** of Met-L-Wood stand up under constant use... help damp vibration, resist denting.

WAINSCOTING in traffic areas gets rough treatment; is a natural for decorative Met-L-Wood use: sustained beauty without upkeep.



CABINETS and enclosures of all kinds gain strength, beauty, life from Met-L-Wood.



X-RAY & RADIATION ROOMS can be attractive as well as safe with lead-cored Met-L-Wood panels, doors.

Detailed data on how Met-L-Wood can serve you, in one or more of its many forms, is yours for the asking. Write for new Bulletin 522. Met-L-Wood Corporation, 6755 West 65th Street, Chicago 38, Illinois.

STRONG
DURABLE
LIGHTWEIGHT

MET-L-WOOD Metal bonded to plywood

For more information, turn to Reader Service card, circle No. 481

What's new IN MATERIALS

materials are recommended for bearings, spacers, bushings, piston rings, inserts, connectors and bases. TFE is filled with glass, carbon, graphite, molybdenum disulfide and mica.

Finishes

▸ Rusty surfaces coated with a new phenolic-vinyl maintenance coating system need not be sandblasted before primer and top coat are applied. Formerly, when all-vinyl systems were used, it was necessary to sandblast the rusty metal surface before applying primer. The coating system was developed by Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

▸ A line of fluorescent paints has been introduced by Titanine, Inc., Morris & Elmwood Avenues, Union, N. J. for use on aircraft and boats. The paints are characterized by good daylight fluorescent color retention and good chemical resistance.

▸ A non-inflammable, non-toxic rust preventive has been introduced by Lehigh Chemical Co., Chestertown, Md. Designated Anderol L-536, the rust preventive is packaged in 16-oz aerosol containers.

Joining materials

▸ A low-fuming filler rod has been developed by Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 46, Wis., for welding high strength bronzes and brasses. The rod is made of manganese bronze alloyed with nickel.

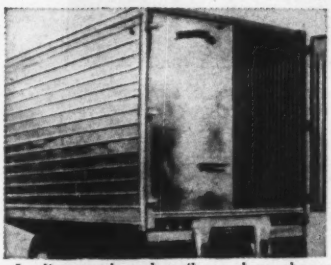
▸ Fenwall Inc., Pleasant St., Ashland, Mass. has developed an adhesive kit that is said to make storing and mixing of epoxy adhesives easier and cleaner. The kit is made up of a clear plastics container containing a glass ampoule filled with a curing agent, and another container containing an epoxy resin. When the glass ampoule is broken, the curing agent runs through a short length of tubing and is mixed with the epoxy resin.

▸ A new method of manufacturing screw threads turns out high strength aircraft bolts capable of sustaining over 2,000,000 cycles at standard fatigue loads. The best currently available aircraft bolt fails at 65,000 cycles under the same fatigue loads. The bolts are available from Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.

For more information, circle No. 463 ➤

HOW ROYALITE SOLVES 3 BASIC DESIGN PROBLEMS:

TOUGHNESS * BEAUTY * ECONOMY



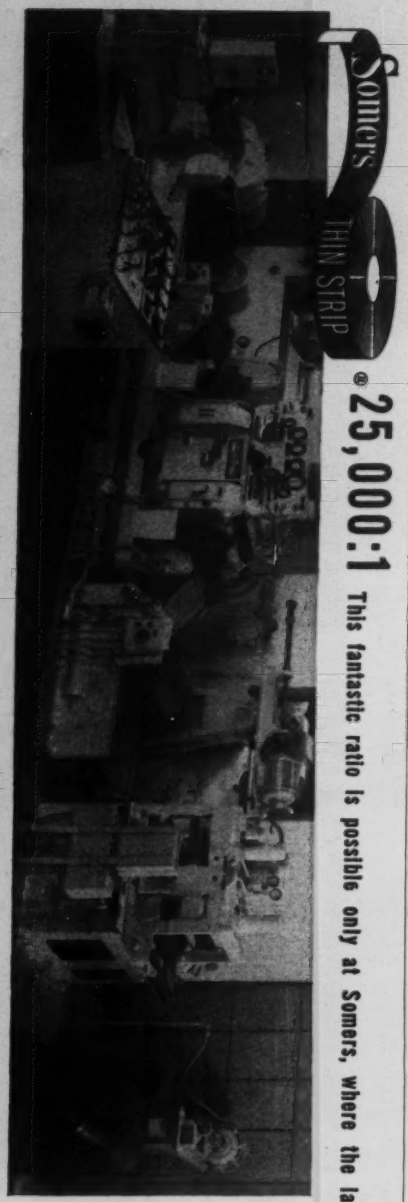
Leading truck and trailer makers choose damage-free Royalite refrigeration panels that are easy to keep kitchen-clean . . . maintain stable temperature . . . keep weight at a minimum . . . and reduce cooling costs.

Royalite, most versatile of thermoplastic sheet materials, has proven itself time and again to scores of manufacturers . . . in hundreds of varied applications. **Toughness:** Tote boxes of Royalite have built-in resistance to hard knocks. Seamless, easily cleaned, no sharp edges to snag or splinter, quiet, impervious to oils, grease and most chemicals, really lasts. **Beauty:** luggage of Royalite allows modern concepts in molded designs . . . lightweight, pleasing textures, wide range of built-in colors, impact, scuff, and dent resistant, easily cleaned, lasts longer in travel. **Economy:** picnic cooler with pure white Royalite liner provides a non-conductor material with built-in thermal breaker at no extra cost . . . seamless, easily cleaned, odorless, can't rust, deep drawn, modest equipment and labor costs, fabricating techniques permit use on popular priced items. Find out how you can benefit from U.S. Royalite. Let one of our plastics engineers call on you. There is no obligation. Write for information.

Tote boxes by United States Rubber, *Luggage* courtesy of Crown Luggage Co., *Picnic Cooler* courtesy of Coleman Co. Inc., *Refrigeration Panels* courtesy of Trailmobile, Inc.

US Royalite® A.B.S. THERMOPLASTIC SHEET

US RUBBER **United States Rubber**



25,000:1 This fantastic ratio is possible only at Somers, where the latest equipment produces thin strip down to .001", as wide as 25".

With the installation of one of the largest Sendzimir mills in the non-ferrous industry, Somers is prepared to meet the broadest range of dimensional specifications, since it is already supplying thin strip down to .0001" in narrower widths.

Pure Nickel, Monel, Inconel and Inconel "X" are produced in gauges from .0001" to .020". Stainless Steel, electrolytic Copper and its alloys, such as Brass, Nickel Silver and Phosphor Bronze from .0001" to .010".

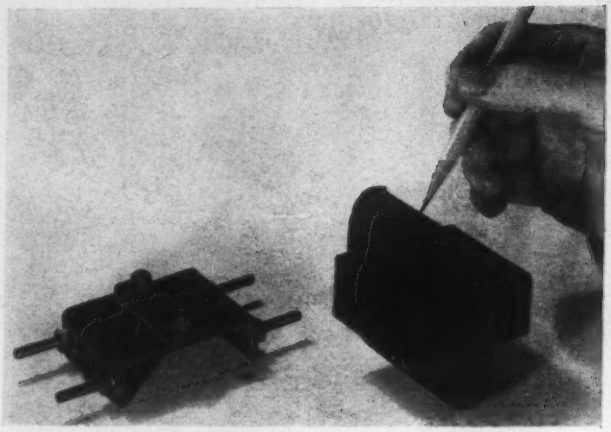
For a complete survey of your strip problems at no cost or obligation, write for field engineer or Confidential Data Blank.

Somers Brass Company, Inc.
108 Baldwin Ave. Waterbury, Conn.

For more information, circle No. 412

MATERIALS AT WORK

Transformer—cont'd from p 12



One-piece molding *(right) holds both primary and secondary coils.*

for the windings. Terminals are square-head bolts which are set in keyways molded into the inside wall. The entire unit is then transfer molded of a polyester elastomer to provide a hermetically sealed, totally insulated package.

According to Atlas Powder Co., polyester was selected because of its good strength, dielectric properties, heat and chemical resistance, and excellent moldability.

Conical section *of collector is given hard chromium carbide surface.*

Hard surfacing protects dust collector

Excellent wear resistance, low cost, ease of fabrication and flexibility are the reasons given for the use of hard surfaced mild steel plates in the redesign of a shell for a cyclone dust collector.

According to Thornton Co., the switch from unsurfaced mild steel to mild steel hard surfaced with an alloy flux is expected to result in a 7½-year extension in the life of the part. Moreover, when repairs do become necessary they can be more easily accomplished.

Although hard surfacing is often performed before the part is com-

(Advertisement)

Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

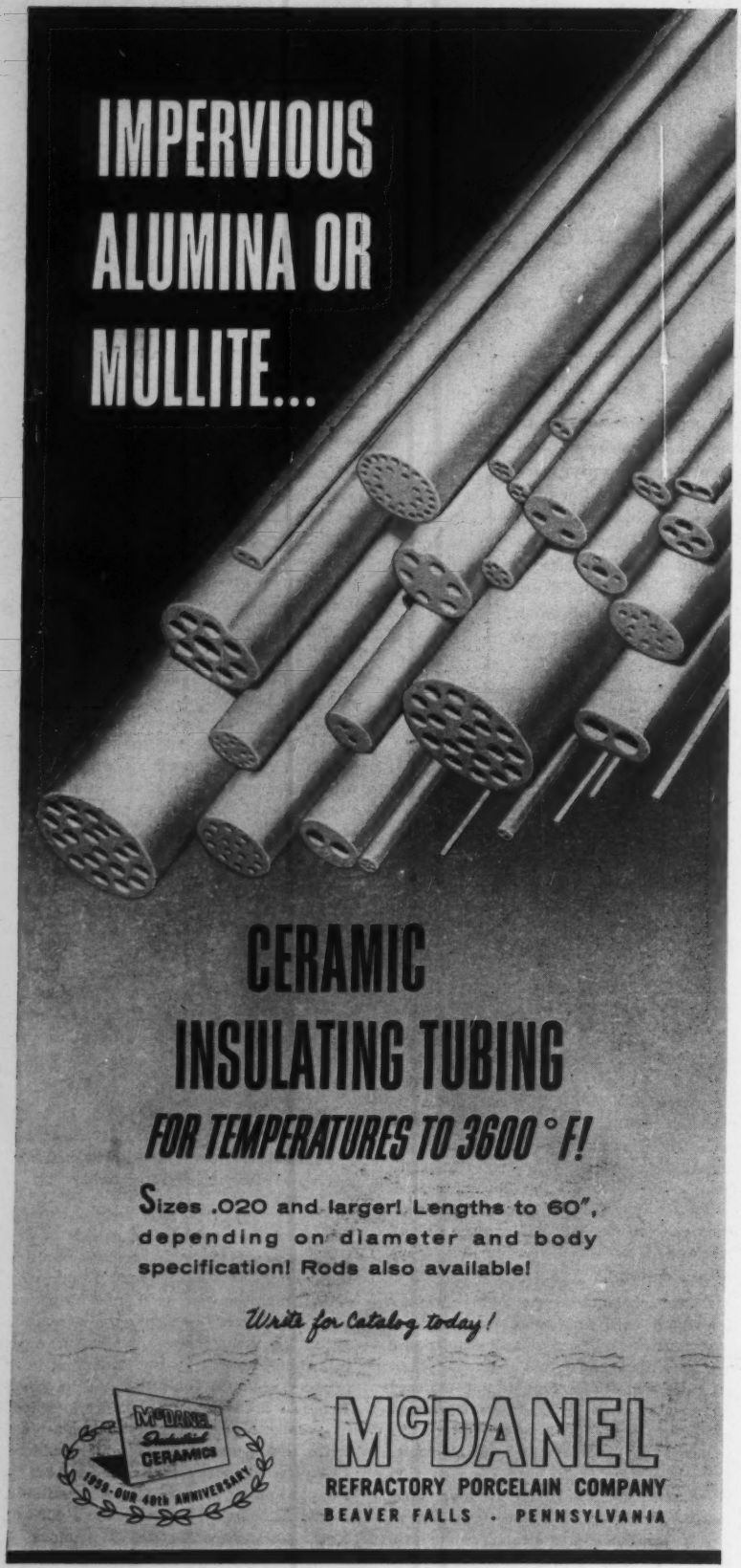
These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

For more information, turn to Reader Service card, circle No. 467

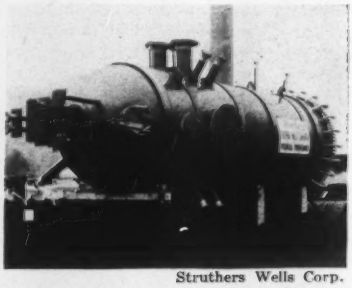


pletely fabricated, Thornton chose to fabricate the shell first and then hard surface because the shape of the finished shell lent itself readily to continuous circumferential welding. The shell consists of two ¼-in. thick mild steel plates: the body is a large cylindrical section; the dust collector a conical section joined to the bottom of the body during installation.

Alloy flux used

To hard surface the insides of the two parts, they are rotated on turning rolls under a fully automatic welding head mounted on a ram-type fixture. As the shells rotate, the head automatically feeds a continuous mild steel electrode into a flux-covered electric arc. The arc combines the electrode, flux and base metal into a molten pool which later solidifies into a weld metal deposit containing hard chromium carbides. The alloy in the deposit comes from the alloy-containing flux. The deposited ¼-in. bead is indexed, or stepped over, after each complete revolution so that adjacent beads overlap to give a uniformly smooth surface.

According to Lincoln Electric Co.,

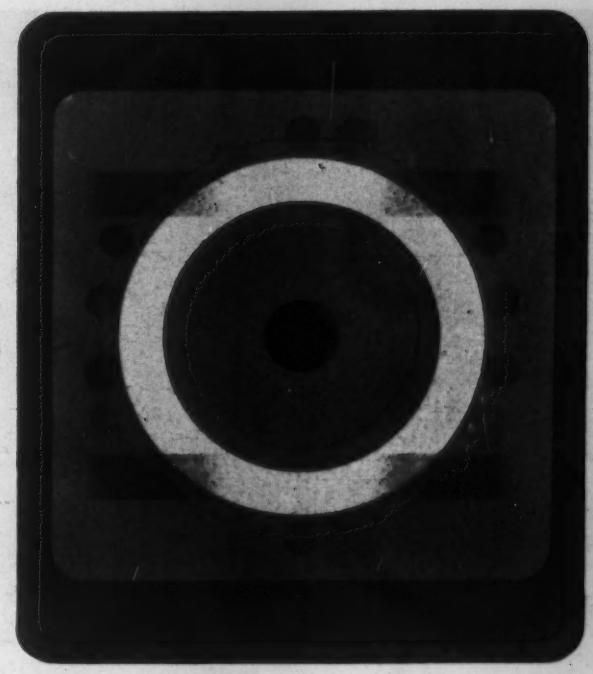


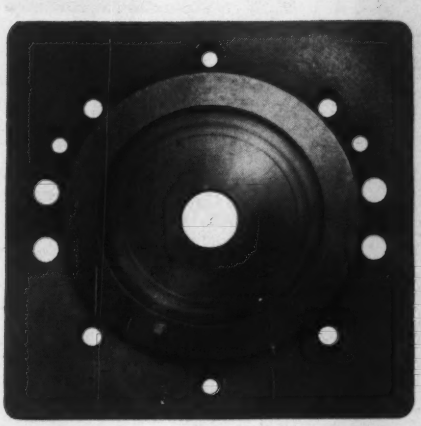
Struthers Wells Corp.

Precision-built tank—The huge pressure tank shown above is 35 ft long, 9 ft in dia and weighs 140,000 lb—yet tolerances are proportionately as close as those on a fine watch. The tank, to be used in a new atomic reactor at the National Advisory Committee for Aeronautics' Plum Brook Research Station, was designed and machined to fit perfectly when lowered into position amid a nest of 68 pipes already in place in concrete. The tank is composed of carbon steel and stainless-clad steel.

For more information, turn to Reader Service card, circle No. 419

Radiograph shows porosity which caused markings to be fuzzy





Alloy casting for faceplate of aircraft instrument

End of a fuzzy face

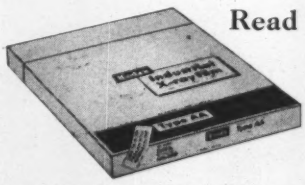
SEE-AT-A-GLANCE clarity is an absolute *"must"* for aircraft instruments. So when one in development appeared with fuzzy numbers and index marks on its face, the cause and cure had to be found.

Sperry Gyroscope Company maintains a large and efficient x-ray testing department, hence the casting for the instrument face was promptly radiographed.

What the radiograph revealed was marked porosity. The conclusion was that the material used in applying the figures was being absorbed and sharp delineation was impossible. Therefore, a change in casting technic was indicated.

This is typical of the ways radiography helps the foundryman make sure only satisfactory work is delivered—make sure he is building and keeping a reputation for high-quality castings. If you would like to know how it can help you, call your x-ray dealer—or the Kodak technical representative—and talk it over.

X-ray Division . . . EASTMAN KODAK COMPANY . . . Rochester 4, N. Y.



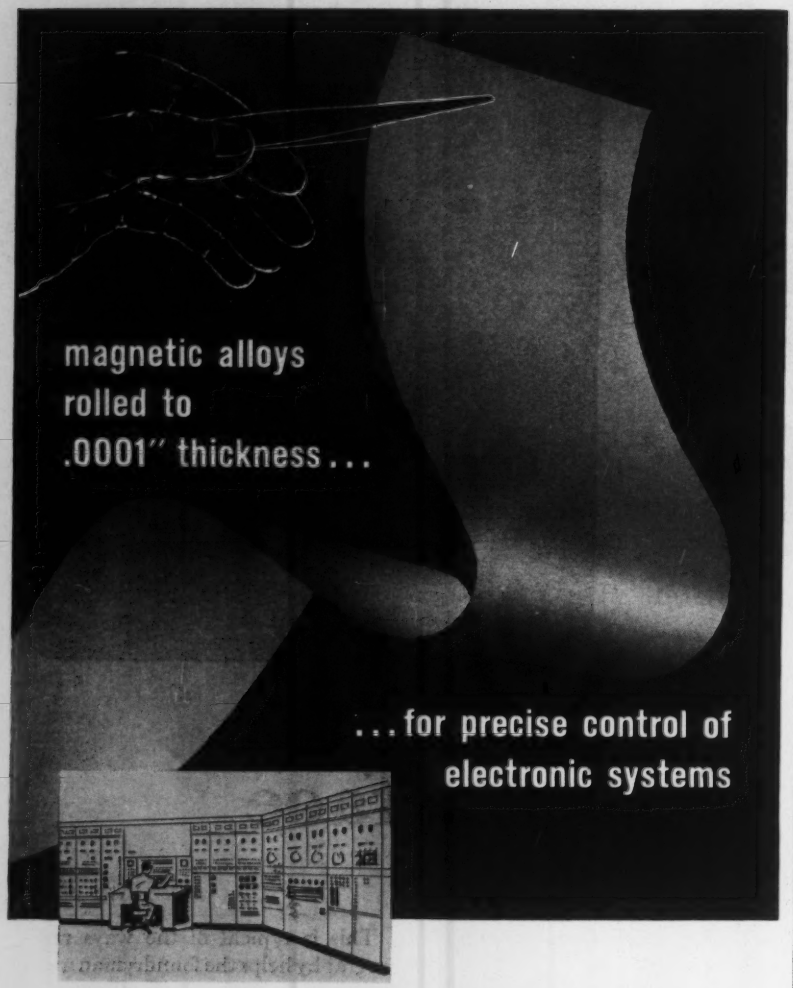
Kodak Industrial X-ray Film Type AA

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
- Gives high subject contrast; increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

Kodak

For more information, turn to Reader Service Card, circle No. 367

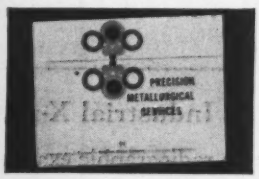


Now you can obtain high magnetic permeability alloys such as 4-79 Moly Permalloy, Alfenol, and HyMu "80" in cold rolled strip and foil in **production** quantities! The unique and newly expanded facilities of Precision Metals Division are geared to produce ultra-thin metal strip and foil in any quantity and in virtually any alloy.

Precision Metals strip and foil for development and production offer these special advantages:

uniform magnetic properties
thicknesses from .010" to .0001"
dimensional uniformity
extremely close tolerances
excellent surface characteristics

For specific requirements, Precision Metals can also furnish custom alloys to your own specification in the form you need. Write today for fully illustrated facilities booklet, DE-3.



HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

For more information, turn to Reader Service card, circle No. 507

materials costs for electrode and flux are low and welding speeds (submerged arc) are fast. Total cost of the process depends on the size of the hard surfaced area, thickness of deposit, type of deposit required, and ease with which the job can be set up for welding.

Liquid Sealant Eases Bearing Replacement

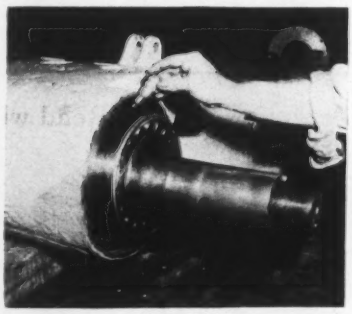
The use of Loctite sealant (a liquid polymeric adhesive of undisclosed composition) has made it possible to replace a 9-in. spherical roller bearing located in the jaw of a rock crusher in less than 1 hr instead of the 3-4 days previously required—with a resultant saving of $155.

The saving is achieved by mounting the bearing with a slip fit and retaining with the sealant rather than using the interference press fit previously used.

When assembled with a press fit, it was previously necessary to 1) bore the housing i.d., 2) deposit weld metal on the exposed surface, and 3) rebore to provide an interference fit. It then took two men several hours to install the bearing.

Now, the o.d. of the bearing and the i.d. of the housing are simply wiped with a clean rag, the mating parts roughed with emery paper, and sealant applied to the surfaces. The bearing is then assembled with a light push fit (total tolerance is approximately 0.003 in.). The sealant between the bearing and the housing starts to harden in 30 min and is completely hardened in 12 hr.

(more Materials at Work on p 182)



***Bearings are retained** with special liquid polymeric adhesive.*

Build Quality in Your Line with

BISHOP TUBING AND PLATINUM PRODUCTS

"Metals for Precision and Performance"

Quality begets quality — it's an established axiom that premium products must begin with quality components. BISHOP has been producing platinum and precious metal products since 1842 . . . *precision* stainless steel tubing since 1931. The BISHOP family of metal products includes a broad variety of components for the designer, engineer . . . just to mention a few:

Capillary Tubing—stainless grades, standard sizes up to .130" OD
Platinum & Platinum Alloy Wire—#50 to #3 B & S Gauge
Clad Metals—base and precious metals in various combinations
Glass-To-Metal Sealing Alloys—low expansion alloys
Thermocouple Wire—noble metal and noble metal alloys
Tubing—nickel, stainless, platinum, special alloys up to 1" OD
Tubular Fabricated Parts—all varieties—conventional forming operations
Composite Wires—base and precious metals in various combinations
Platinum Contacts, Discs, Laboratory Apparatus

CATALOGS, DATA SHEETS SENT PROMPTLY ON REQUEST

Begin your next design with *unexcelled* quality BISHOP component materials. Write, wire or phone Malvern 3100.

J. BISHOP & CO.

platinum works

MALVERN, PENNSYLVANIA

For more information, turn to Reader Service Card, circle No. 377

When You Have a SEATING Problem . . .

When you want to know what type of seating to use . . . your best bet is to check such factors as dimensional stability, tensile strength, compression—deflection characteristics, and—price. This means you'll want to check on Reynofoam—the urethane foam that, by statistical analysis, best meets *all* requirements for commercial seating.

Ask Reynolds Chemical For The Answer

A pioneer in the development of urethan foam, Reynolds Chemical Products can deliver to you *now* foam seating — cored or uncored — in *any* commercial quantity. Without obligation, write for technical assistance . . . for information . . . for the answer to *your* seating questions.

Reynolds Can Mold It — If Anyone Can!

REYNOLDS CHEMICAL PRODUCTS COMPANY

WHITMORE LAKE, MICHIGAN

DIVISION OF STUDNITZ GREENE CORP.

For more information, turn to Reader Service card, circle No. 504

MATERIALS AT WORK

***Slotted filter screens** are lowered into wells.*

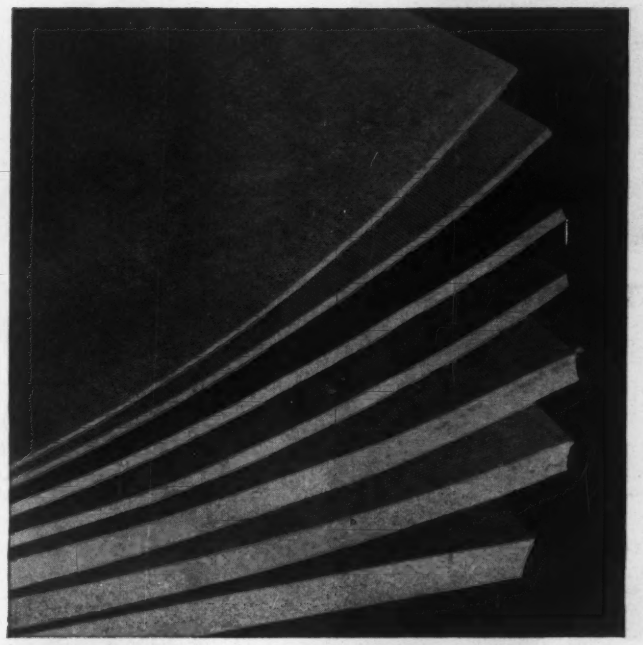
Stainless Well Filters Replace Carbon Steel

Perforated stainless steel has replaced carbon steel for filter screens used to permit continuous flow of water in large water wells.

Type 304 stainless steel was specified to replace carbon steel for several reasons: 1) the carbon steel filter became clogged with rust and stopped the flow of water; 2) highly acidic, or extremely hard, water reduced the life of carbon steel filters to as little as five years; 3) mineral deposits on the slots in the screen had to be removed by pouring acid down the well and later neutralizing. The acid caused considerable damage to the carbon steel.

The new stainless filter screens not only have greater corrosion resistance and superior strength, but cost less as well. The screens are made by punching slots ¾ in. wide and 1½ in. long over the entire area of a 5-ft long, ¼-in. thick plate. The slotted plates are then welded into cylinders 14 in. in dia; as many as 15 cylinders may be joined for use in a single well.

DON'T MISS AN ISSUE — Changing your address? If so, please let us know two months in advance. With such notice, which we need for efficient operation, we will do our best to see that you don't miss an issue. Be sure to include your new postal zone number.



Silicone Sponge Rubber

remains flexible at extreme temperatures
—100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:
COHRlastic R-10470 meets many specifications. Some are listed below:

AMS 3195
AMS 3196
MIL-R-6130A type 2
Boeing BMS 1-23
Martin MC1 4546
Martin MB 6130
Bendix ES 0709
Douglas DMS 1597
Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

1 ASTM D 1056-56T

CHR products include:
COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*
COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*
Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*
Allied Products — *COHRlastic silicone cements and conductive gasketing*

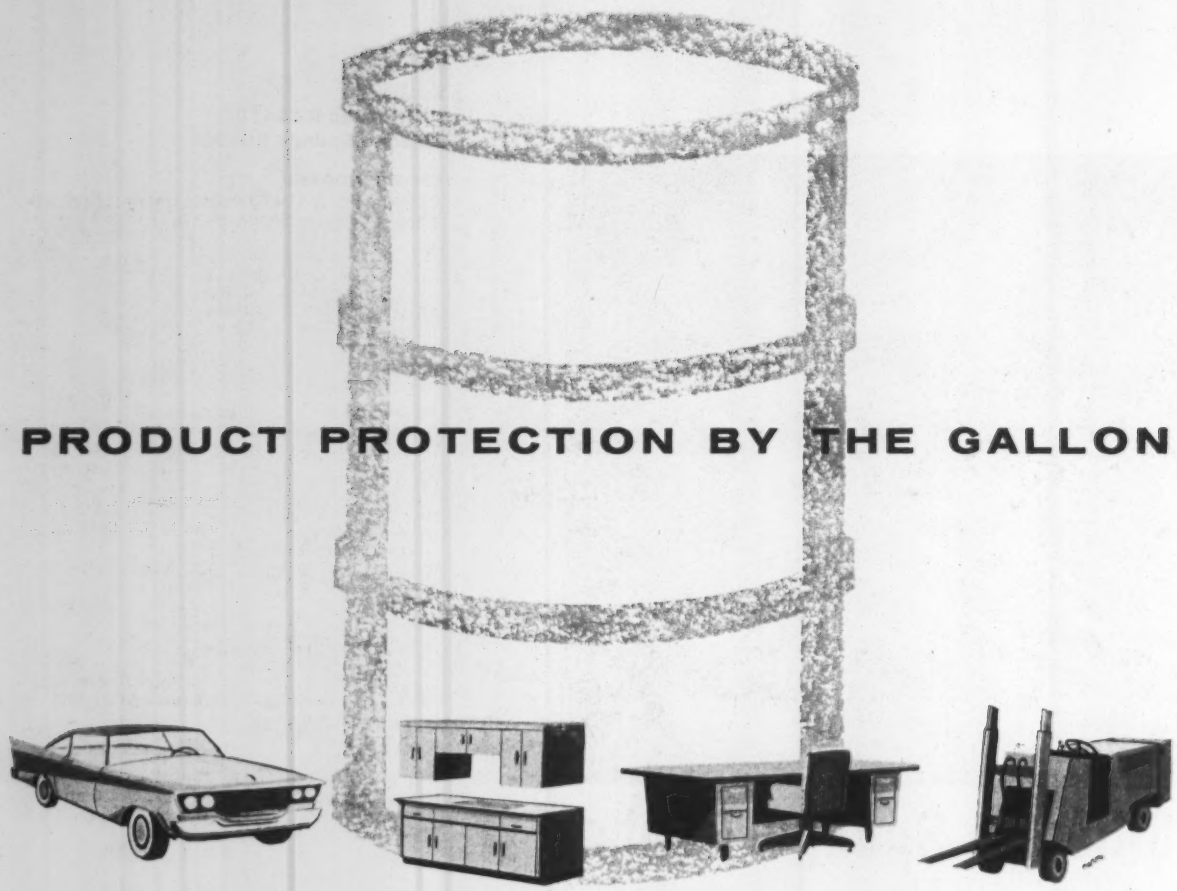
CHR Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut

For more information, turn to Reader Service card, circle No. 445

PRODUCT PROTECTION BY THE GALLON

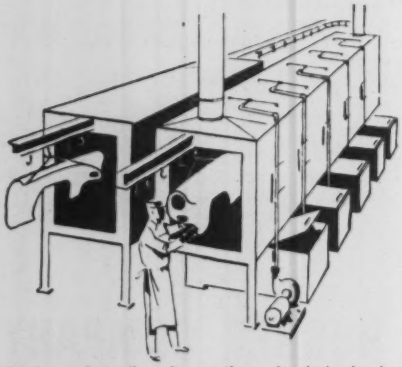


WITH AMCHEM GRANODINE!

One of the most widely used metal finishing chemicals, Amchem Granodine is the most effective pre-paint treatment yet developed for the protection of fabricated steel products.

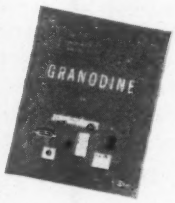
The non-metallic phosphate coating produced by Amchem Granodine provides an effective base for durable paint finishing and greatly improves the corrosion resistance of the finished product. A variety of Granodizing processes are available for a wide range of finishing operations . . . to assure your products of greater usability through lasting protection.

It may be well worth your while to investigate cost saving, efficient Amchem Granodine—today's most modern metal finishing chemical for steel. Check Amchem where service goes beyond the product with a complete program of technical and engineering assistance!



Granodizing process may be applied by power spray (shown on left), dip system or by hand application.

Write for Bulletin 1380 with Selection Chart to help you choose the Granodine type for your specific needs—and bulletins featuring other Amchem chemicals of vital interest to the fabricator of steel products.



AMCHEM AMCHEM GRANODINE

Amchem Granodine is another chemical development of **Amchem Products, Inc.**, Ambler, Pa. Formerly American Chemical Paint Company, Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Granodine are registered trademarks of Amchem Products, Inc.

For more information, turn to Reader Service card, circle No. 365

PRICES AND SUPPLY

...AT A GLANCE

More high density polyethylene and Mylar will soon be available as a result of Du Pont's latest expansion plans. According to the company, two new plants, to be completed early in 1960, will 1) increase manufacturing capacity of Mylar polyester film by 30%, and 2) allow Du Pont to begin commercial production of linear polyethylene.

Consumption of aluminum in 1958 amounted to 1.8 million tons, or 8% below the 1.925 million tons used in 1957. However, according to R. J. Reynolds, Jr., president of Reynolds Metals Co., 1959 will see increased use of aluminum. Mr. Reynolds bases his optimism on the following factors: 1) price has not increased since Aug '56; 2) many new heavy-duty structural applications are planned; 3) greater use in the building industry is expected; and 4) the amount of aluminum used per automobile should increase sizably. Primary aluminum production in 1958 amounted to 1.55 million tons as compared to the 1.68 million tons produced in the peak year of 1956.

Commercial quantities of Zefran—Dow Chemical Co.'s acrylic fiber—and "small quantities" of Rovana—Dow's new fiber made from natural gas and salt—are now available. The Zefran fiber, based on polyacrylonitrile, will be produced at an annual rate of 12 million pounds. Prices have not as yet been established. The Rovana fiber, similar to Dow's Saran, will not be available in commercial quantities for some time. However, limited quantities are obtainable at about $1.25 per lb.

Domestic consumption of silver in 1958 ended up about 10% below that of 1957—85 million ounces as compared to 95 million. According to Handy & Harman, however, consumption in 1959 "will exceed the 1958 figure." Price of silver in 1958 was somewhat below that of 1957: high was 90⅜¢ per troy oz and low was 88⅝¢ per troy oz, as compared to 1957's high of 91⅜¢ and low of 89⅜¢.

Use of reinforced plastics was 10% higher in 1958 than in 1957. According to the Reinforced Plastics Div., Society of the Plastics Industry, Inc., total consumption in 1958 amounted to 185 million pounds, as compared to 168 million in 1957. Polyester resins far outweighed all other resins and glass was the major reinforcing material. Major uses of reinforced plastics in 1958 were as follows: aircraft and missiles, 10% of total; boats, 20%; construction, 17%; consumer products, 13%; transportation, 16%; appliances, containers and electrical, 4% each; pipe tanks and ducts, 3%; and miscellaneous, 9%.

More styrene monomer at lower prices will result from Monsanto Chemical Co.'s recent 40-million-pound-per-year increase in rated capacity. According to the company, the additional capacity plus a reduction in the price of benzene (a major styrene monomer raw material) will enable the company to reduce prices starting Apr 1. The new price will be 12¢ per lb.

(Prices of Materials on p 187)

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.

If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

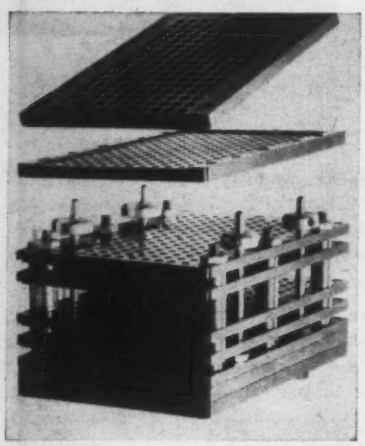
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded*, rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

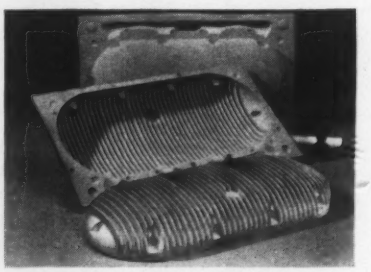
Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding*. It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.



For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
1403 Walck Road, North Tonawanda, N. Y.

For more information, turn to Reader Service card, circle No. 456

Prices of Materials

Changes since last quarterly report in December are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	.46-.51
Butadiene-Styrene	.16-.30	.22-.32
Butyl	.22-.26	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural[b]	.29	—

[a]Less than carload quantities.
[b]Average spot price for month of Dec.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.40-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	**4.10-6.65**	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.25-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25
Ingot (99-99.9%)	.27
Foil (5-0.5 mil)	.61-.67
Alloy Ingot (13, 43, A132, 214)	.28
Sheet (1100, 3003; 3-0.03 in.)[a]	.43-.46
Plate (1100, 3003, 5050, 3004, 5052)[a]	.42-.45

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.47	.49	.50
Seamless Tubing	.50	.53	.53
Rod (not f.c.)	.47	.49	.50
Wire	.47	.50	.51

COPPER

Ingot (elec)	.29
Sheet, Strip (hot rolled)	.53
Seamless Tubing	.53
Rod, Drawn	.50
Rod, Free Cutting	.61
Wire	
Round	.34
Square, Rectangular	.38
Magnet	.40

LEAD

Common Grade	.13

MAGNESIUM

Pig (98.8%)	.35-.36
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	.99

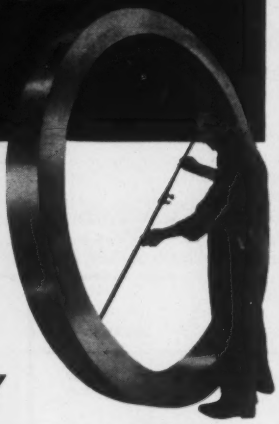
[a]Delivered price.

(continued on p 188)

Edgewater

ROLLED

rings



ACCURATE ROLLING

SAVES MACHINING

REDUCES SCRAP LOSS

ASSURES HIGH QUALITY

Cost reduction, achieved through the use of Edgewater steel rings, is due to savings in machining time and reduced scrap loss. Edgewater rolled rings are formed to tolerances so close that a minimum of machining is required. Weldless rings are rolled from solid steel blocks by a process which produces a wide variety of cross-section shapes. Diameters are from 5 to 145 inches.

WRITE for bulletin describing Edgewater Rings.

Edgewater Steel Company

P.O. Box 478 • Pittsburgh 30, Penna.

For more information, turn to Reader Service Card, circle No. 405

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	1.70-1.82
Bars, Rod	4.25-5.40
Plate	5.00-8.50
Sheet, Strip	6.90-14.35
Wire	5.50-9.50

ZINC

Prine Western	.11½
Die Casting Alloys[a]	.14
Sheet	.26
Ribbon	.22
Plates	.20

[a]Alloys 2, 3, 5.

METAL POWDERS

Aluminum [a,b]	.39
Brass[a]	.33-.49
Copper (elec or red.)[a]	.43
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.45
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$15-17/troy oz
Platinum	$52-55/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	80
Zirconium (sheet, strip, bar)	25-35

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 190)

HOW TO SOLVE PRODUCT DESIGN PROBLEMS WITH

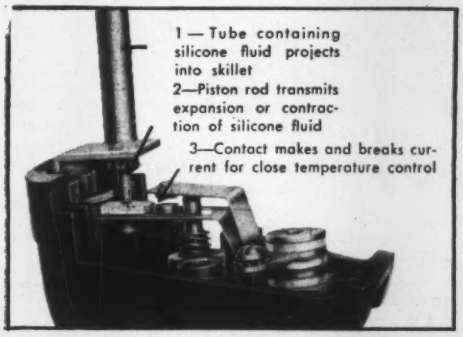
GE SILICONE IDEAS

Silicone rubber for wire insulation adds improved physical properties to excellent electrical properties

Always valued for its high performance electrical characteristics at high temperatures, silicone rubber insulation for wire now has improved physical properties. A true elastomer, GE silicone rubber is suitable for thin wall (.012") wire construction, does not tend to cold flow under clamps, can be bent double without cracking, stays flexible down to −150°F.

Even when exposed to a direct flame, G-E silicone rubber still insulates, won't release toxic fumes. Withstands current overloads of 300%-400%, provides a safety margin for intermittent high temperature operation in Class B equipment. Excellent dielectric strength stays high throughout life; service to 500°F—and to 600°F for shorter periods. Features high ozone, moisture and weather resistance, long shelf life.

No damage occurs when you wrap silicone rubber insulated wire around a hot soldering iron, proof of silicone rubber's remarkable heat resistance.


1 — Tube containing silicone fluid projects into skillet
2—Piston rod transmits expansion or contraction of silicone fluid
3—Contact makes and breaks current for close temperature control

New appliance thermostat uses silicone fluids for faster, closer temperature control

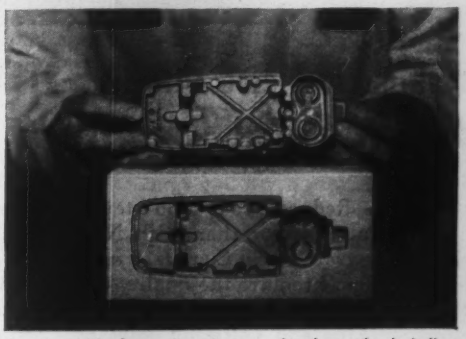
General Electric silicone fluids, because of their high coefficient of expansion and thermal stability, make possible the extremely accurate temperature control provided by the new G-E appliance thermostat. Reaction time is faster than with bimetallic elements; cost fully competitive.

This is only one example of creative engineering with G-E silicone fluids. Their unique properties—small change in viscosity with temperature, chemical inertness, excellent resistance to shear, oxidation and high-temperature breakdown—make them ideal for such applications as dash pots, vibration dampers, heat transfer fluids, fluid transmissions, etc.

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV (room temperature vulcanizing) silicone rubber will do all this and more. Cures without voids at room temperature in any time you select up to 48 hours. Stable up to 600°F. Tough, elastic, bonds well to primed surfaces. Has good resistance to fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.



Sample mold of complex part reproduced exactly, including undercuts. RTV cures without voids, without shrinkage.

OPERATION upturn GENERAL ELECTRIC

Write for more information

Section D10DD3, Silicone Products Dept.
General Electric Company, Waterford, N. Y.

Please send me further data on:

☐ Silicone Rubber Wire Insulation ☐ Silicone Fluids
☐ Silicone RTV Rubber

Name_____ **Title**_____

Company_____

Address_____

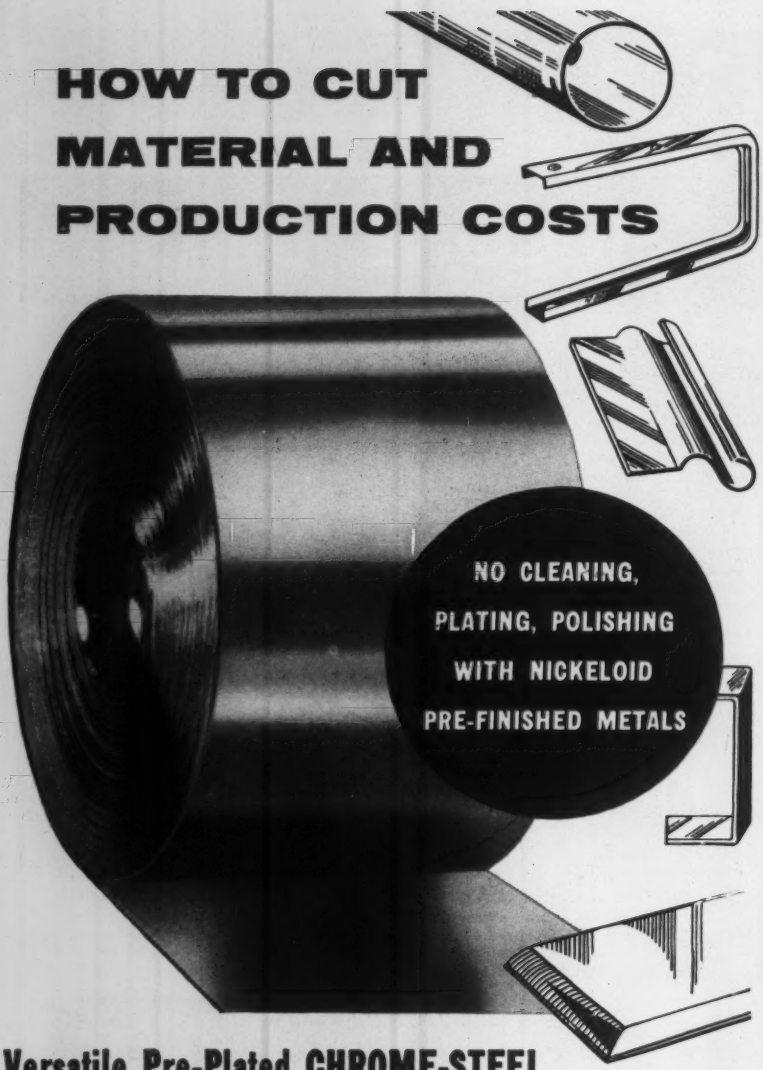
City_____ **Zone**_____ **State**_____

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

For more information, turn to Reader Service card, circle No. 454

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1898

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 6, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania **Sales Offices Throughout the U.S.A.**

For more information, turn to Reader Service card, circle No. 464

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, H.R.	5.10	7.52	—
Sheet, C.R.	6.27	9.27	—
Strip, H.R.	5.10	7.57	8.40
Strip, C.R.	7.42	10.80	—
Bar, H.R.	5.67	8.30	6.72
Bar, C.F.	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.43	.44-.48	.41-.46	.51-.55
321[a]	.47	.56	.55	.66
347[a]	.56	.65	.65	.80
Martensitic				
410[a]	.28	.34	.30	.40
416	.29	.34	.31	.48
403	.28	.34	.30	.40
420, 440	.34	.41	.40	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.31-.32	.52
442	.33	.40	.37	.56
431	.38	.44	.41	.56
446	.39	.44	.43	.70
High Mn				
202[a]	.37	.43	.40	.49
Extra Low C				
304L	.48	.56	.54	.63
316L	.70	.81	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

[a]Ingot price approx 60% of billet price.

METAL POWDERS ($/lb)[a]

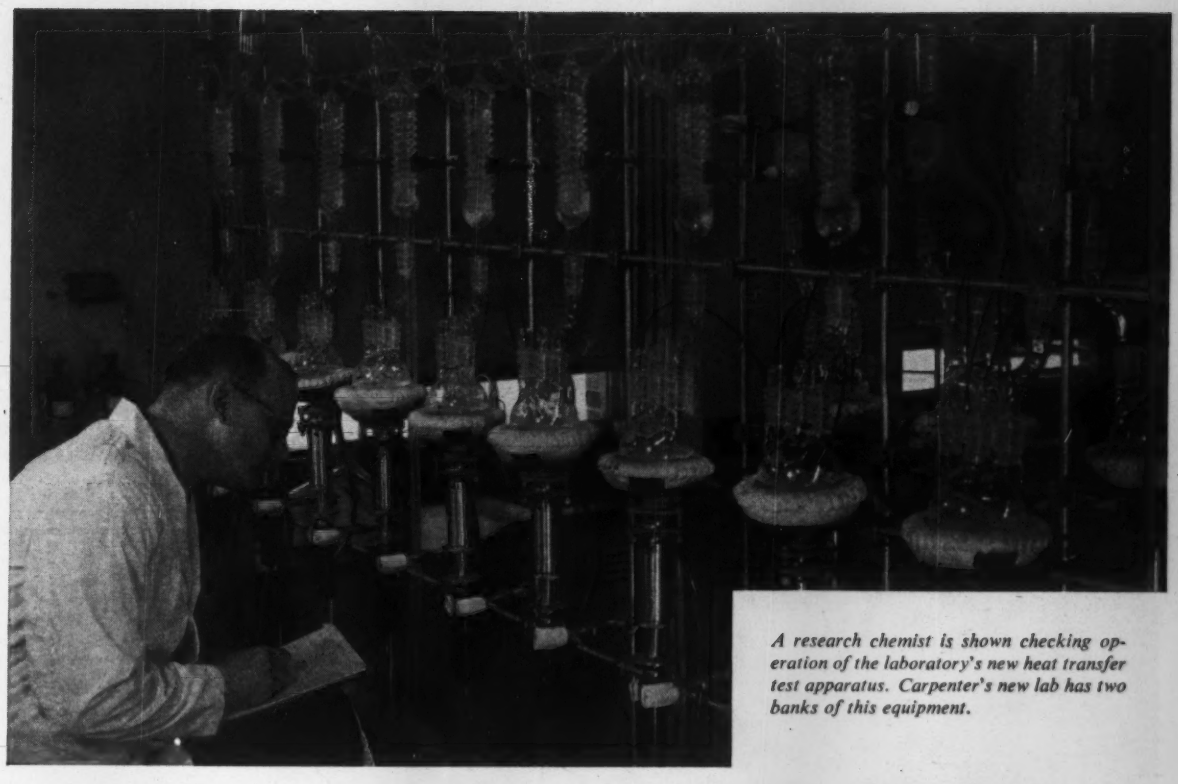
Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.07
316	1.26

[a]Price for —100 mesh.

IRON ($/gross ton)

Pig	66-67

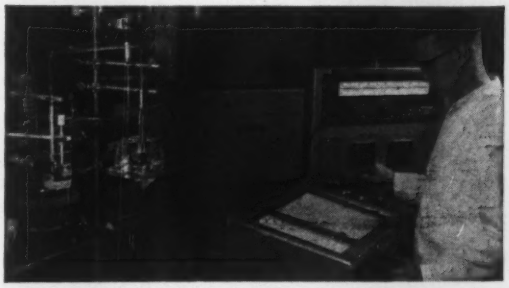
(continued on p 192)



A research chemist is shown checking operation of the laboratory's new heat transfer test apparatus. Carpenter's new lab has two banks of this equipment.

Carpenter's new corrosion laboratory can predict stainless tubing performance on your job

A corrosion engineer makes final adjustments on the new Corrosometer.



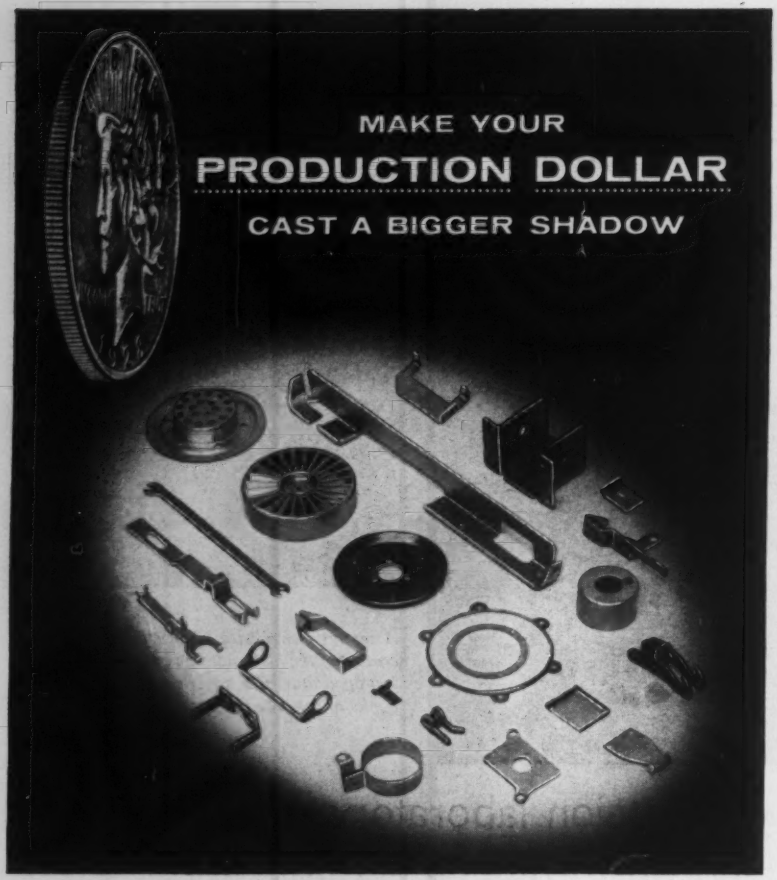
This new electro-chemical equipment enables Carpenter to make more thorough study of the behavior of stainless steels and thus gather more background for the development of new and improved alloys.

This new laboratory is considered the largest and best equipped of its kind among companies producing specialty steel exclusively. Heat transfer apparatus, Corrosometer, multi-sample tester, electro-chemical equipment, high pressure, elevated temperature corrosion testing, and stress corrosion cracking equipment give Carpenter the facilities to help solve your corrosion problems and select the right material for any of your needs. Carpenter . . . first in corrosion research . . . first in corrosion control . . . first in stainless tubing and pipe economy. Authorized distributors in over 40 cities, coast to coast. Or write to The Carpenter Steel Company, Alloy Tube Division, Union, N.J.

your master key to cost-saving corrosion control

Stainless Tubing & Pipe

For more information, turn to Reader Service card, circle No. 459



Federal Short Run Stampings may be your answer

Stretch your production tooling dollar up to 80% by using Federal "Controlled Tolerance" Short Run Stampings. That's the savings you get by using the Federal Stamping method instead of conventional tooling methods. You can *put a new product* on the market or make improvements in *existing products* with a *minimum tooling investment*. When quality, fast delivery and price are important factors, try Federal first for any quantity stampings from two pieces to 10,000. Size limitations are 10" x 14" and 3/8" in thickness. Send your print or part to the nearest plant for a Federal Analyzed Quotation.

Write for

FREE CATALOG

Tells where and how you can save money using Short Run Stampings. Gives design tips that reduce stamping costs. Ask for your copy today.

QUALITY STAMPINGS
FEDERAL
IN SMALL QUANTITIES

3 PLANT LOCATIONS

FEDERAL TOOL & MANUFACTURING CO.
3552 Alabama Ave., Minneapolis 16, Minn.
FEDERAL SHORT RUN STAMPING, INC.
952 Lyell Avenue, Rochester 6, N.Y.
FEDERAL STAMPING COMPANY
7352 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service Card, circle No. 375

PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	60	70	81
Nickel	52	63	73
Monel	54	64	74

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10- 9.75

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

For more information, circle No. 453 ➤

What's the limit on cold-headed wire parts?

Some of these items cold-headed from wire exceed the supposed limits of just a few years ago; who can say how far the frontiers of cold-heading will be advanced in the next few years?

The key to cold-heading's phenomenal success is the wire metallurgy. Steel wire for cold-heading is a Bethlehem specialty, and our metallurgists have had years of experience. Bethlehem cold-heading-quality wire is made to rigid standards. It is uniform in analysis and free from injurious surface defects. Thorough inspection, at every stage of production, is behind every ton we ship.

At your invitation we will gladly study your products, equipment and process, and recommend the grade of steel that will perform the best. Then we'll carefully produce the steel to meet your needs.

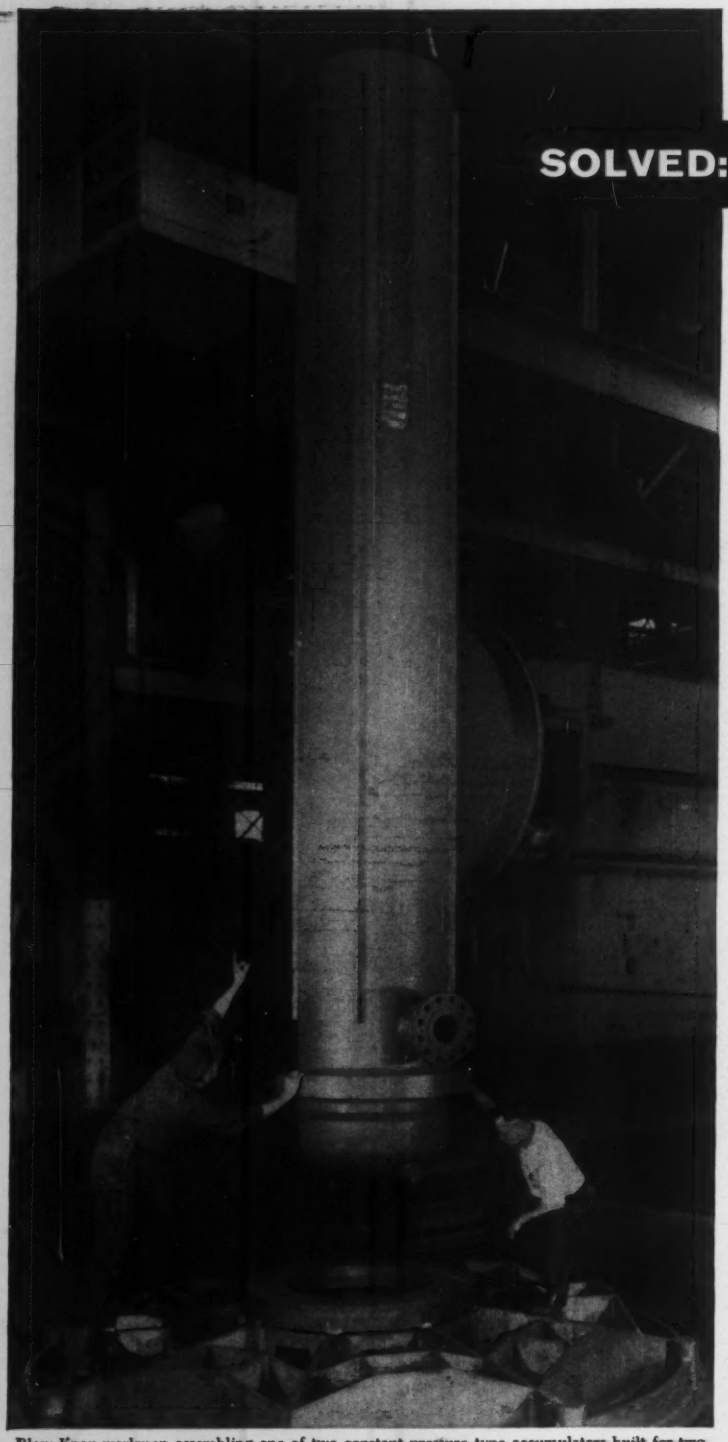
Bethlehem makes nearly every kind of steel wire. Why not discuss your cold-heading or other production problems with one of our technical men? There are many ways in which our engineers might be able to help improve your production of cold-headed items. Just phone the nearest Bethlehem district sales office, or write direct to the address below.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton

SANDUSKY CASTING

for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3½" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly downtime. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems,* too.

Write to us at Sandusky, Ohio. Ask for latest Bulletin #200.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

For more information, turn to Reader Service Card, circle No. 406

Five Major Conferences Set For Next Two Months

■ Starting this month and continuing through May, five of the leading technical associations, in cooperation with several other technical groups, will hold major conferences on engineering materials, processes and design.

Four of the five conferences—sponsored by the American Society for Metals, the American Welding Society, the Metal Powder Industries Federation and the American Society of Mechanical Engineers—will be held in conjunction with annual expositions. The fifth, sponsored by the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers, is a special meeting.

Western Metal Congress—ASM

The 11th Western Metal Congress and Exposition is scheduled for March 16-20 at the Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles. According to the ASM, this year's show is expected to top last year's and will be "loaded with new, improved, helpful materials and equipment." As in the past, all new developments will be "explained and demonstrated by scientists, metallurgists and engineers."

Technical programs at the Congress will be presented by the American Society for Metals, American Welding Society, Society for Nondestructive Testing and the Metals Branch—Southern California Section, AIME. In addition, 30 other technical societies will co-sponsor the event.

In all, over 100 papers will be delivered. Some of the subjects to be covered include: explosive forming, recent advances in the physics of metals, materials for extremely high temperatures, radiation effects in materials, high temperature brazing, pressure vessels, effects of advances in mill practices on material characteristics, ultra high strength steels for missiles, magnesium-thorium alloys, and titanium and titanium alloys.

For further information, contact Ray T. Bayless, assistant secretary, American Society for Metals, 7301 Euclid Ave., Cleveland 3.

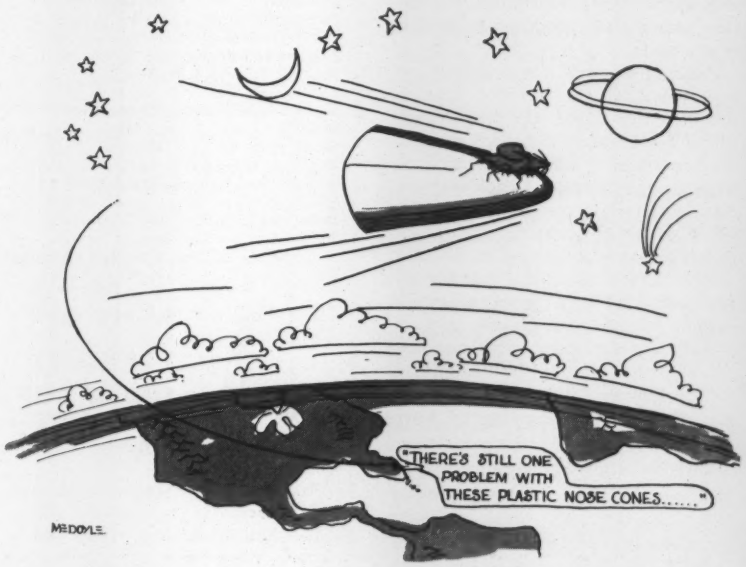
Stress-Corrosion Fracture—AIME

A special conference on the Physical Metallurgy of Stress-Corrosion Fracture has been set for April 2-3 at the Mellon Institute, Pittsburgh. The Conference is sponsored by the Corrosion-Resistant Metals Committee of the Institute of Metals Div. of the Metallurgical Society (a constituent organization of the American Institute of Mining, Metallurgical and Petroleum Engineers), in cooperation with the Electrochemical Society, the National Association of Corrosion Engineers and the American Society for Testing Materials.

The program will center around these general subjects: theoretical aspects of stress-corrosion fracture; new experimental advances in stress corrosion and fracture; and mechanisms of stress-corrosion cracking, including environmental and metallurgical aspects and the behavior of specific materials. Emphasis will be placed on physical-metallurgical, surface-chemical, and solid state physics aspects of the phenomena.

Papers will be preprinted and circulated in advance and the sessions will take the form of summaries of papers with extended discussion and exchange of scientific information.

For further information, contact



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News of Industry

the Metallurgical Society of AIME, 29 W. 39th St., New York 18.

Welding—AWS

The 40th Annual Meeting and 1959 Welding Show is set for April 6-10 at the Hotel Sherman and International Amphitheatre, Chicago.

This year's Welding Show, which is slated to be the largest ever held, will be geared toward those engineers, executives, etc. who are responsible for the purchase or specification of equipment and materials.

The 1959 Annual Meeting, sponsored by the American Welding Society and held in conjunction with the Electric Welding Conference of the American Institute of Electrical Engineers, will deal with such things as: stainless steels, processes and procedures, heat effects on steel weldments, design considerations, titanium and zirconium, weldability of steel and cast iron, aluminum alloys, and brazing.

For further information, contact the American Welding Society, 33 W. 39th St., New York 18.

Powder Metallurgy—MPI

The 15th Annual Meeting and 1959 Powder Metallurgy Show will be held April 20-22 at the Sheraton Cadillac Hotel, Detroit. According to the Metal Powder Industries Federation, practically all of the available space has been contracted and this year's show promises to be one of the best.

Some of the subjects scheduled to be covered at the Meeting (which this year will include the first Design Clinic for Powder Metallurgy) are: fundamentals of powder metallurgy, some new applications of lead powder, sintered aluminum compacts, effect of lithium stearate additions and nitrogen atmosphere on sintered compacts, use of powder metallurgy for diffusion bonding of cemented carbide to steel, automobile applications of powder metallurgy, and machinability of sintered iron compacts.

The Design Clinic, scheduled for the afternoon and evening of April 22, will consist of an open forum discussion, with audience participation, on design, tolerances, properties, finishes and other subjects pertinent to an understanding of powder metallurgy. Purpose of the clinic is to show potential users of

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E. W. Bliss Co., Canton and Toledo, Ohio and Hastings, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
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Vulcan Foundry Co., Oakland, Calif.
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Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
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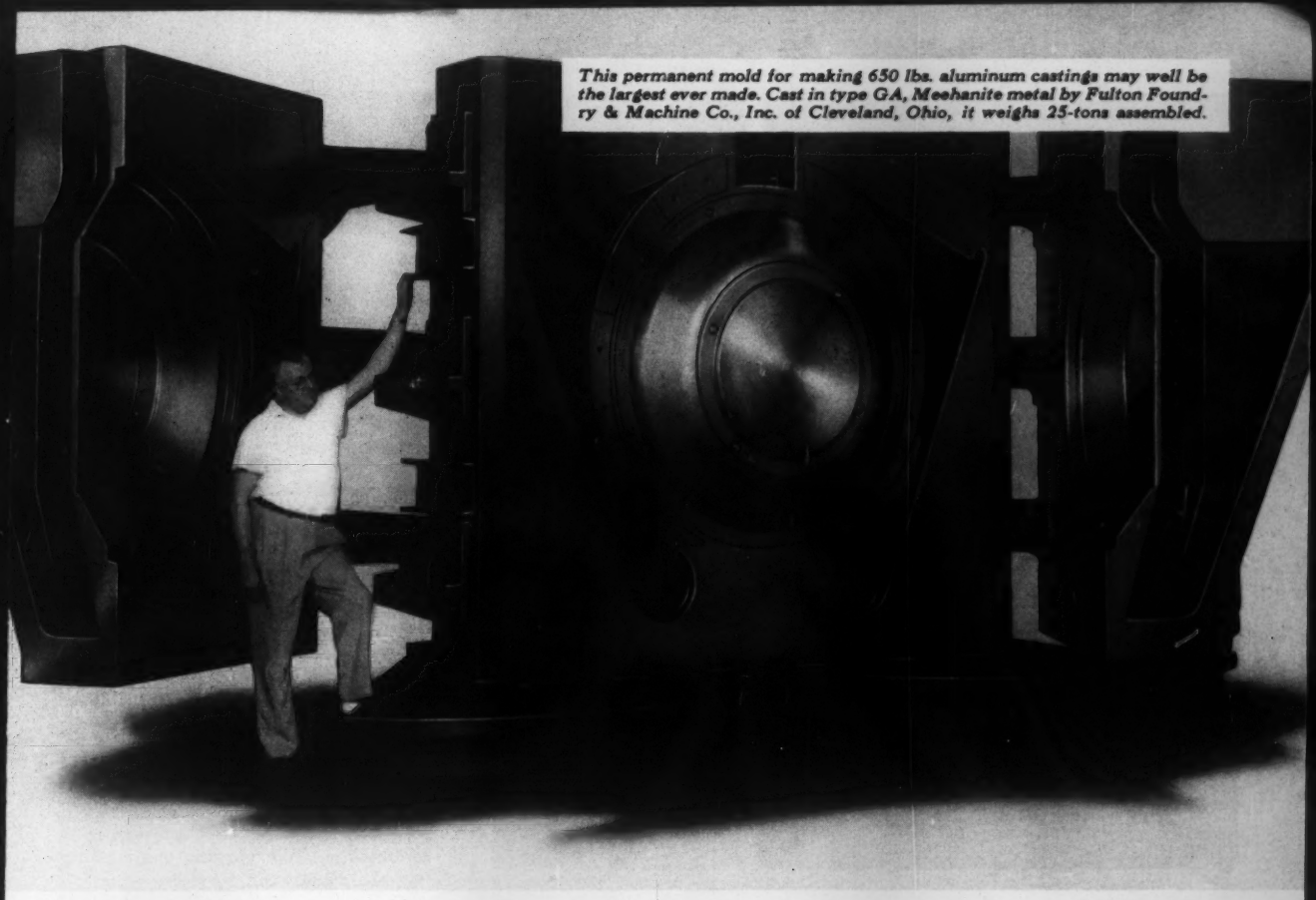
Bulletin 23 — "Meehanite® — The Metal For Permanent Molds."

Write today to Meehanite Metal Corporation, Department 3C, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

For more information, circle No. 433



This permanent mold for making 650 lbs. aluminum castings may well be the largest ever made. Cast in type GA, Meehanite metal by Fulton Foundry & Machine Co., Inc. of Cleveland, Ohio, it weighs 25-tons assembled.

Meehanite permanent molds offer resistance to heat checking and distortion from thermal shock.

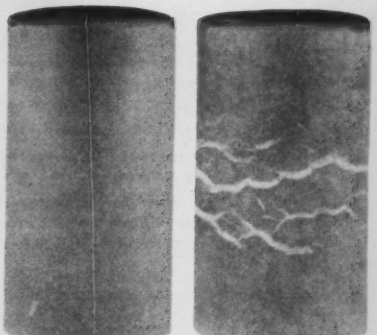
Premature cracking or disintegration of surface is a serious problem to the users of permanent molds. Severe service conditions demand the selection of a metal with a dense close-grained structure which maintains dimensional accuracy and resists the disastrous effects of thermal shock.

Meehanite metal has the ability to more than meet these requirements and is used extensively for permanent molds in the production of both ferrous and non ferrous castings, glass, plastics and other materials. The huge mold illustrated is proof of the confidence placed in Meehanite.®

The chief advantage of a Meehanite mold is consistent uniformity of structure throughout the casting. Meehanite's dense, stabilized structure resists thermal shock, insures freedom from distortion and dimensional changes. Easily machined, it provides the smooth, highly polished surface so essential to good finish and long production life.

Meehanite molds can be cast closely to shape to reduce machining operations. Also, they may be heat treated or flame hardened where high hardness is required.

Write for free literature: Bulletin 23 — "Meehanite® — The Metal For Permanent Molds."



The block on the right reveals what happens when an ordinary permanent mold material is suddenly heated and cooled. The Meehanite block on the left, given same test, shows complete freedom from surface cracking.

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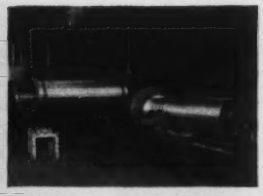
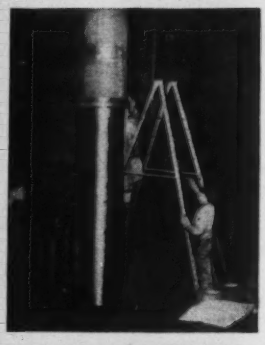
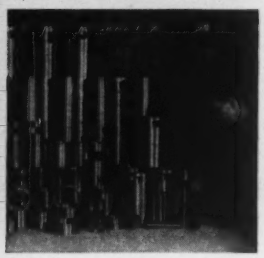
MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK







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For more information, turn to Reader Service card, circle No. 437

News OF INDUSTRY

powder metallurgy parts what is being done today and how it can benefit them.

For complete details on registration, technical program and exhibitors, see the Apr '59 issue of M/DE.

Design Engineering—ASME

The annual Design Engineering Show and Conference, which in only four years has become one of the nation's largest expositions, will be held May 25-28 at Conventional Hall, Philadelphia.

The Design Show, managed by Clapp & Poliak, Inc., will be devoted to research and development and is expected to consist of over 400 individual company exhibits covering such things as metals, nonmetallics, fasteners, finishes and coatings, shapes and forms, mechanical components, power transmission equipment, electrical and electronic components, hydraulic and pneumatic components, and various engineering equipment and services.

The Design Engineering Conference, sponsored by the Machine Design Div. of the American Society of Mechanical Engineers, will again cover materials and mechanical and electrical aspects involved in product design. One of the highlights of the Conference will be the sessions devoted to engineering materials. Subjects to be covered include: latest developments in plastics, metals and ceramics for service above 1000 F, and latest developments in materials and coatings to resist chemical and atmospheric corrosion.

For complete details on registration, technical program and exhibitors, see the May '59 issue of M/DE.

Engineers

O. M. Bundy has been appointed manager, New Products Div., Clark Controller Co.

Dr. Arthur B. Backensto, Jr., is now research metallurgist, Alan Wood Steel Co.

I. J. Karassik has been appointed consulting engineer and manager of planning, Harrison Div., Worthington Corp.

Dr. George Joris has been named manager of research, **Donald A.**

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36 W. 44th Street, New York 36, N. Y.

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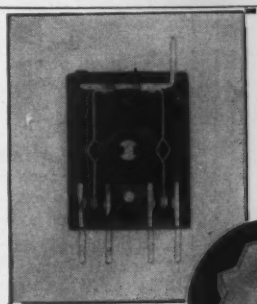

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"GRAPH-I-TITE" is the first impervious graphite. It is immune to thermal shock, non-contaminating, not wetted by molten metal, and is unaffected by practically all corrosives, even at elevated temperatures above 1,000° F.

Custom grades of Graphite Specialties graphite are regularly produced with a critical level of purity, almost unbelievable strength, and fine, uniform texture. Other properties of density, porosity, and machining characteristics can be supplied to requirements.

Components and equipment made from Graphite Specialties graphite grades can feature low neutron-capture cross section and high scattering cross section for moderator, reflector, fuel elements, structural parts and piping in nuclear reactors; seals, bearings and other mechanical shapes featuring temperature resistance to 5,000° F. and hardness to 5 Mohs; pipe and cylinders for electric furnace construction; processing equipment for difficult applications such as handling chlorine up to 5,000° F; and rocket nozzle inserts with a very low erosion rate.

Most types of Graphite Specialties graphite can be furnished in rod, tube, sheet and block form, or can be molded or extruded in special shapes, or can be machined to close tolerance.

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News OF INDUSTRY

Rogers manager of project analysis, and **Dr. Frank Porter** assistant to director of research, Central Research Laboratory, Allied Chemical Co.

Anker Gerald Christensen has been appointed director of manufacturing, Read Standard Div., Capitol Products Corp.

Raymond S. Holmes has been named vice president, research and development, Winchester-Western Div., Olin Mathieson Chemical Corp.

Dwight A. Wrigley has been named assistant general manager, Riverside-Alloy Metal Div., H. K. Porter Co., Inc.

Ulrich Reimer has been appointed vice president and director of research, Fremont Industries, Inc.

E. P. Richards has been named chief engineer at a new petrothene polyethylene plant of U. S. Industrial Chemicals Co., a division of National Distillers and Chemical Corp.

Kenneth A. Arata has been appointed manager of process engineering for decorative laminated plastics, and **John C. Pitzer** has been named manager of process engineering for industrial Formica products, Formica Corp., a subsidiary of American Cyanamid Co.

John J. Marick is now senior project engineer, Test Equipment Div., Consolidated Diesel Electric Corp.

Dr. Gerard E. Claussen has been appointed director of research and welding engineering, Arcrods Corp.

James S. Galbraith has been named manager of semiconductor operations, Microwave Asso. Inc.

Vernon H. Patterson has been appointed metallurgical engineer, Vanadium Corp. of America.

Dr. Carl E. Barnes has been elected vice president for research, Minnesota Mining & Mfg. Co.

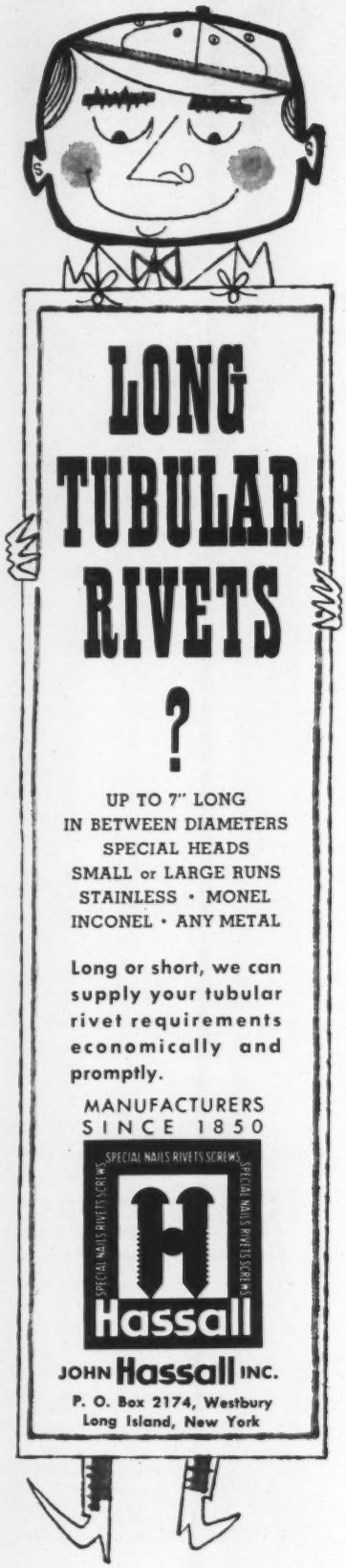
F. H. Ford, Clark Bros. Co., has been elected vice chairman, Gas Turbine Group, National Electrical Mfgrs. Assn.

Irving Dulberg has been named manager, research and quality control, J. H. France Refractories Co.

Ernest H. Schanzlin is now chief engineer, Tuthill Pump Co.

Thor N. Rhodin has been made a member of the faculty of metallurgical engineering, Cornell University.

W. M. Watkins, Jr., has been named chief process engineer, Fulton Syl-



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Temperature gauges tell the story. Special Parco Cleaners and Bonderites in Cold Bonderite System operate 40° to 75° cooler!

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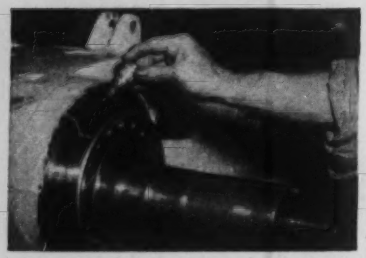
"We replace 9" bearings in less than an hour— and save $155 each!"

Says David B. Cook, President Acme Road Machinery Co., Inc. Frankfort, New York



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News OF INDUSTRY

phon Div., Robertshaw-Fulton Controls Co.

Marian Szczepanski is now director of research, Wheel Trueing Tool Co.

Gilbert R. Semans has been named chief steel metallurgist, A. M. Byers Co.

John E. Marek has been appointed manager, product engineering, Elwell-Parker Electric Co.

Companies

Swedlow Inc., is the new name of **Swedlow Plastics Co.**

Roto-Finish Co. has purchased **Ransohoff, Inc.**

Crippen Laboratories Inc., a subsidiary of Foster D. Snell, Inc., has moved to a new building at 1500 Guilford Ave., Baltimore 2, Md.

Westinghouse Electric Corp.'s East Pittsburgh Div. has formed a new power control and communications department, and V. B. Baker has been named manager of the new unit.

Carlon Products Corp. of Aurora, Ohio, has purchased the assets of **United Pipe and Tube Co.**, Lubbock, Tex.

Marine Colloids, Inc., is the new company name which resulted from the merger of **Algin Corp. of America** and **Seaplant Corp.** Main Company offices are at 24 State St., New York City.

Houston Instrument Corp., 1717 Clay Ave., Houston 3, Tex., is a newly formed company for the development, manufacture and sale of laboratory instruments and specialized industrial instruments for the petroleum and chemical industries.

Carlisle Corp. has acquired **Tensolite Insulated Wire Co., Inc.**, of Tarrytown, N. Y.

Northrop Corp. is the new name of **Northrop Aircraft, Inc.**

Trio Laboratories, Inc., has moved to new and larger quarters at Plainview, L. I., N. Y.

Koppers Co., Inc., has announced plans for the construction of a new research center at Monroeville, Pa.

Snyder Corp. is the new name for **Snyder Tool & Engineering Co.**

C. H. Dexter & Sons, Inc. has purchased **Standard Insulation Co., Inc.**,

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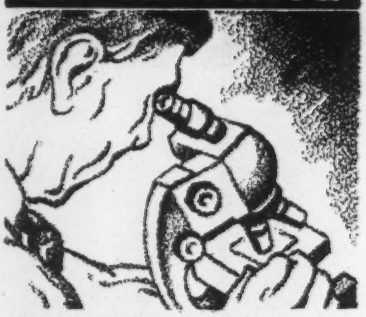

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Model SZH153 with temperatures to –95° F. 110V; 60 cycle, single phase.

Model SZH653, larger capacity, temperatures to –85° F. 110V, 60 cycle, single phase.

Model SZHC657. Same capacity as SZH653 but attains temperature as low as –140° F. 220V, 60 cycle, single phase.

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Description	Model	Cu.Ft.	Temp. Range		Outside Dim.			Inside Dim.		
			Rm. 70°	Rm. 110°	L	W	H	L	W	H
Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42"	28"	42¾"	23"	9"	12½"
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60"	28"	42¾"	47"	15"	16"
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60"	28"	42¾"	47"	15"	16"
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42"	28"	41"	30"	16"	18"

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1. The names and addresses of the publisher, editor and managing editor are: Publisher, William P. Winsor, 400 E. 52nd St., New York, N. Y.; Editor, H. R. Clauser, 59 S. Washington Ave., Hartsdale, N. Y.; Managing Editor, John B. Campbell, 75-20 113th St., Forest Hills, L. I., N. Y.

2. The owner is: Philip H. Hubbard, 2 Bon Mar Road, Pelham Manor, N. Y.; Profit Sharing Trust, 430 Park Ave., New York 22, N. Y.; William P. Winsor, 400 East 52nd Street, New York 22, N. Y.; Fred P. Peters, 45 Forest Drive, Short Hills, N. J.; H. Burton Lowe, 17 Birchdale Lane, Flower Hill Estates, Port Washington, N. Y.; Merald F. Lue, Newtown Turnpike, R.F.D. 4, Westport, Conn.; Kathleen A. Starke, 266 Bedford Park Blvd., Bronx 58, N. Y.; Gessner G. Hawley, 328 W. 58th St.; John F. LeViness, Jr., 10 Oak St., Floral Park, Long Island, N. Y.; John Y. Cunningham, 412 E. 55th St.

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WILLIAM P. WINSOR,
Vice President and Publisher

Sworn to and subscribed before me this 8th day of September, 1958.

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(My commission expires March 30, 1960.)

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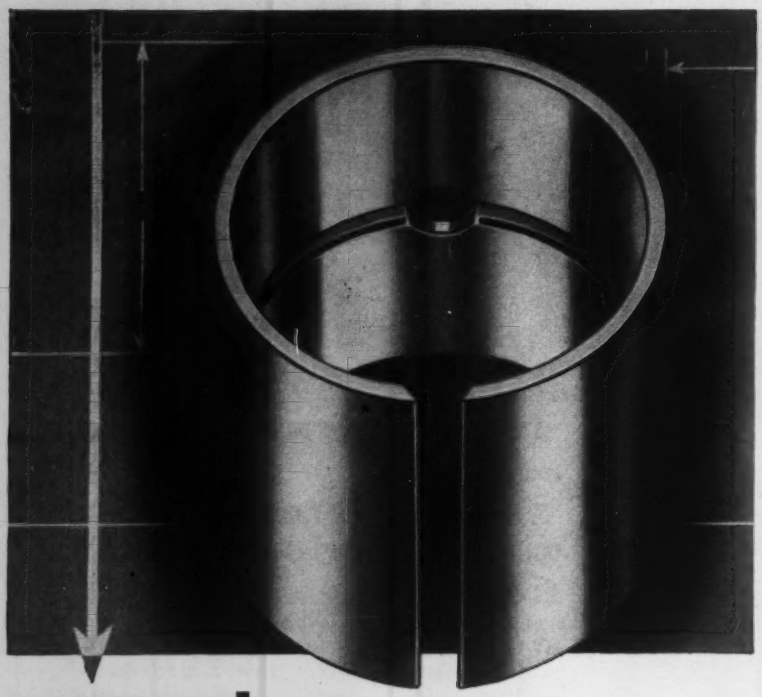

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Kennecott Copper Corp. has acquired **Okonite Co.,** which will become a subsidiary of Kennecott.

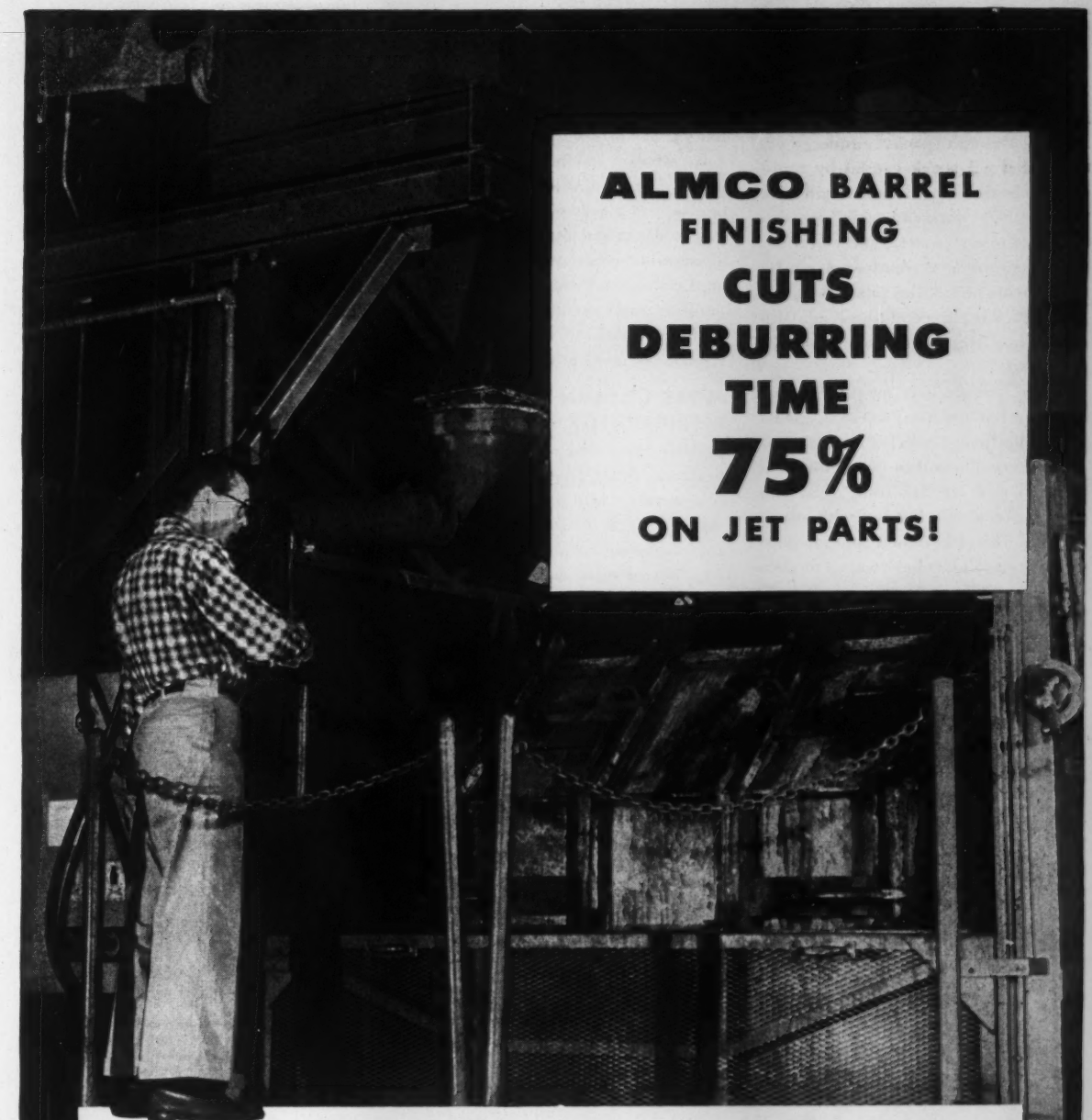
Split Ballbearing, a division of Miniature Precision Bearings, Inc., has begun operations in a new $600,000 plant at Lebanon, N. H.

Societies

American Foundrymen's Society has nominated the following officers: president—Charles E. Nelson, Dow Chemical Co.; vice president—Norman J. Dunbeck, International Minerals & Chemical Corp.; and directors—Norman A. Amrhein, Federal Malleable Co.; Cecil N. King, Chrysler Corp.; Robert E. Mittlestead, Akron Standard Mold Co.; A. J. Moore, Canadian Bronze, Ltd.; William H. Oliver, American Radiator & Standard Sanitary Corp.; and James N. Wessel, Puget Sound Naval Shipyard.

American Society of Heating and Air-Conditioning Engineers has elected the following 1959 officers: president—Arthur J. Hess, Hess-Greiner & Polland; first vice president—Walter A. Grant, Carrier Corp.; second vice president—John Everetts, Jr., consulting engineer; and treasurer—John H. Fox, Honeywell-Controls, Ltd. Elected to the council of the Society are: William J. Collins, Jr., consulting engineer; Harold A. Lockhart, Bell & Gossett Co.; Rolland S. Stover, R. S. Stover Co.; and George W. F. Myers, Myers Engineering Equipment Co. Elected to

PROPERTIES of most engineering materials can be found in the second edition of M/DE's *Materials Selector* reference issue, published in October. Names and addresses of suppliers are also listed.



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News OF INDUSTRY

the Society's Committee on Research are: Albert Giannini, Carrier Corp.; Richard C. Jordan, University of Minnesota; Maurice Nelles, Crane Co.; Herbert Nottage, Lockheed Aircraft Corp.; and Paul H. Yeomans, consulting engineer.

Meetings

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th annual meeting. Chicago. Mar 16-17.

AMERICAN SOCIETY FOR METALS, 11th Western metal exposition. Los Angeles. Mar 16-20.

INSTITUTE OF RADIO ENGINEERS, INC., national convention. New York City. Mar 23-26.

AMERICAN SOCIETY FOR QUALITY CONTROL, Rochester Section, 15th annual quality control clinic. Rochester, N. Y. Mar 26.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, and PETROLEUM ENGINEERS, conference on physical metallurgy of stress-corrosion fracture. Pittsburgh. Apr 2-3.

AMERICAN WELDING SOCIETY, 40th annual convention and welding exposition. Chicago. Apr 6-10.

AMERICAN FOUNDRYMEN'S SOCIETY, engineered castings show and 63rd annual castings congress. Chicago. Apr 13-17.

METAL POWDER INDUSTRIES FEDERATION, annual meeting. Detroit. Apr 20-22.

INSTITUTE OF ENVIRONMENTAL ENGINEERS, 3rd annual technical meeting and equipment show. Chicago. Apr 22-24.

METAL TREATING INSTITUTE, spring meeting. Hollywood, Calif. Apr 22-26.

ELECTROCHEMICAL SOCIETY, spring meeting. Philadelphia. May 3-7.

4th annual Design Engineering Conference, American Society of Mechanical Engineers. Convention Hall, Philadelphia. May 25-28.

4th annual Design Engineering Show. Convention Hall, Philadelphia. May 25-28.

AMERICAN SOCIETY FOR TESTING MATERIALS, 62nd annual meeting. Atlantic City. June 21-26.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Seattle, Wash. June 22-26.

Two New Additions to
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1 SILICONES

by ROBERT N. MEALS and FREDERICK M. LEWIS
Silicone Products Department, General Electric Company

1959, 304 pages, $5.95

This book's scope includes the manufacture, properties and applications of the silicones, with data on the properties of silicone resins, fluids and rubbers at high temperatures. It is aimed at design engineers, formulators and manufacturers in all industries who might have interest in silicones as chemicals, rubbers, resins, fluids, greases, adhesives and sealants. Here is a concentrated, readable summary of the technology and applications of silicones.

CONTENTS: Introduction; General Properties; Basic Chemistry of Silicones and of Combination with Other Polymers; Manufacture and Fabrication; Applications of Silicones in Various Fields; Future Prospects of the Silicones and the Broad Silicone Family of Polymers.

2 LAMINATED PLASTICS

by D. J. DUFFIN
Editorial Consultant, Continental-Diamond Fibre

1958, 264 pages, $5.75

Here is a thorough survey of the manufacturing, fabrication, and applications of high- and low-pressure laminates. It covers the various types and grades of raw materials and resins used; their physical characteristics; and includes numerous tables of mechanical, chemical, and electrical properties as related to various kinds of industrial and consumer applications. The book is profusely illustrated with photographs. The fact that the information and illustrations were compiled from a great number of sources with the cooperation of many manufacturers gives the book the broadest possible scope. The appendix features the most accurate and comprehensive list of laminated plastics manufacturers and trade names ever before offered.

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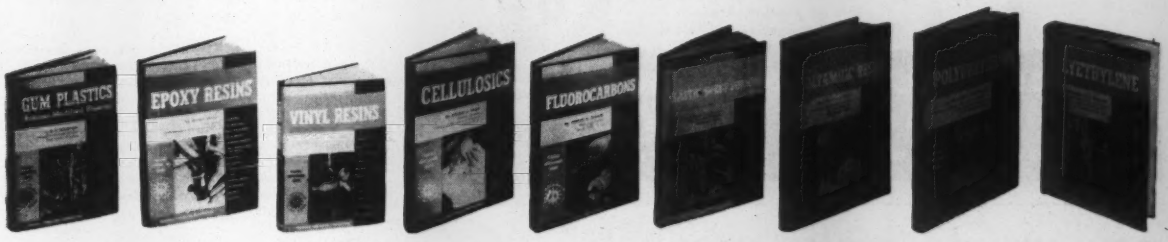

3 GUM PLASTICS

by M. S. THOMPSON
Naugatuck Chemical Division, U. S. Rubber Company

1958, 206 pages, $4.50

4 EPOXY RESINS

by IRVING SKEIST
Consultant, Skeist & Schwarz Laboratories

1958, 308 pages, $5.50

5 VINYL RESINS

by W. MAYO SMITH
Director of Research and Development, Escambia Chemical Corporation

1958, 292 pages, $5.75

6 CELLULOSICS

by WALTER D. PAIST
Celanese Corp. of America, Newark, N. J.

1958, 282 pages, $5.75

7 FLUOROCARBONS

by MERRIT A. RUDNER
Enflo Corporation, Maple Shade, N. J.

1958, 248 pages, $5.75

8 PLASTIC SHEET FORMING

by ROBERT L. BUTZKO
The Auto-Vac Company, Bridgeport, Conn.

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9 POLYAMIDE RESINS

by DON E. FLOYD
Chemical Applications Section, General Mills, Inc., Minneapolis, Minn.

1958, 240 pages, $4.50

10 POLYURETHANES

by BERNARD DOMBROW
Director of Laboratories, Plastics Division, Nopco Chemical Co., North Arlington, N. J.

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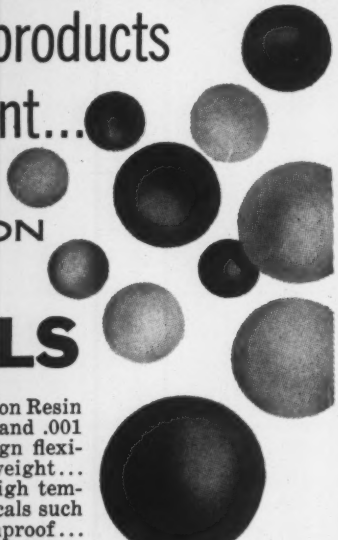

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TECHNICAL LITERATURE

Books

Laminated Plastics. *D. J. Duffin. Reinhold Publishing Corp., New York. 1958. Plastics Applications Series. Cloth, 5 by 7 in., 262 pp. Price $5.75*

This book gives information on the manufacture, fabrication and uses of high and low pressure laminated plastics. Numerous tables give physical, mechanical, chemical and electrical properties. The book also contains 1) a list of manufacturers of high pressure laminates, 2) a brief history of vulcanized fibre and phenolic laminate manufacturing, and 3) a list of U.S. tradenames currently used in the laminated plastics industry.

1958 Book of ASTM Standards: Part 9—Plastics, Electrical Insulation, Rubber, Carbon Black. *American Society for Testing Materials, Philadelphia. 1958. Cloth, 6 by 9 in., 2055 pp. Price $14*

Standards are given for plastics; electrical insulating shellac, varnish, ceramics, plastics, paper and mica; rubber hose, tape and gaskets; rubber-coated fabrics; hard rubber; rubber adhesives; and rubber compounding materials.

The Metal Thorium. *Edited by H. A. Wilhelm. American Society for Metals, Cleveland. 1958. Cloth, 6 by 9 in., 400 pp. Price $10*

This book is intended as a reference source on all that is new and known about thorium as an energy source and as a metal with broad industrial possibilities. The book's 22 chapters contain information on the electronic structure, mechanical properties, corrosion, thermodynamic properties and uses of thorium metal. Information is also given on the hazards associated with thorium metallurgy; the chemical and spectrographic analysis of thorium metal; and effects of irradiation on thorium.

Inorganic Fibres. *C. Z. Carroll-Porczynski. Academic Press Inc., New York. 1958. Cloth, 5½ by 8½ in., 365 pp. Price $11*

The 19 chapters in this book, illustrated with tables, graphs and photos, discuss: glass fibers; glass textiles; glass-reinforced plastics; glass, slag and rock wools; refractory fibers, asbestos; inorganic fiber papers; wire weaving and knitting; metal wools; metallic and metallized yarns; and metallized fabrics.

Effect of Surface on the Behaviour of Metals. *Philosophical Library, Inc., New York. 1958. Cloth, 5½ by 8½ in., 100 pp. Price $10*

This book contains technical papers written by four authors and presented at the Institution of Metallurgists (British) refresher course, 1957. Subjects covered include: 1) methods of preparation and examination of surfaces; 2) influence of surface treatments on the chemical behavior of metals; 3) relationships between surface condition, friction and wear; and 4) influence of surface on the physical properties of metals.

Marks' Mechanical Engineers' Handbook: 6th Edition. *Revised by Theodore Bau-*

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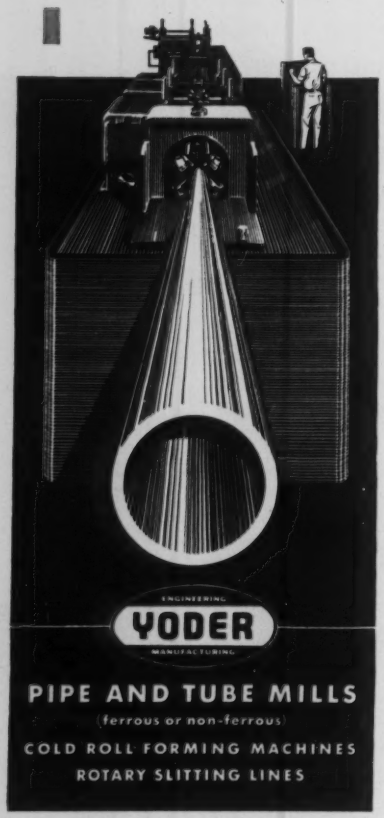

For more information, circle No. 371

TECHNICAL LITERATURE

meister. McGraw-Hill Book Co., Inc., New York. 1958. Cloth, 6 by 9 in., 2270 pp. Price $23.50

Although this book is concerned primarily with mechanical engineering, a number of chapters contain information on iron and steel, nonferrous metals, paints and protective coatings, wood, nonmetallic materials and refractories. Other chapters give information on lubricants and lubrication, and welding.

Reports

Titanium sheet DEPARTMENT OF DEFENSE TITANIUM SHEET-ROLLING PROGRAM—THERMAL STABILITY OF THE TITANIUM SHEET-ROLLING-PROGRAM ALLOYS. *E. S. Bartlett, D. N. Williams, H. R. Ogden and R. I. Jaffee. Nov '58. 46 pp. Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio. (46E)*

Investigations show that Ti-6 Al-4 V alloy has a slight trend toward instability at 900 F for 1000 hr; Ti-4 Al-3 Mo-1 V alloy is susceptible to slight overaging effects under stress at 900 F for 1000 hr; and Ti-16 V-2.5 Al alloy has some instability at 500 F and above.

Fatigue of metals THERMAL FATIGUE OF DUCTILE MATERIALS: PART 1—EFFECT OF VARIATIONS IN THE TEMPERATURE CYCLE ON THE THERMAL-FATIGUE LIFE OF S-816 AND INCONEL 550. *F. J. Clauss and J. W. Freeman, Lewis Flight Propulsion Laboratory. Sept '58. 61 pp. Available from National Advisory Committee for Aeronautics, 1512 H St. NW, Washington 25, D.C. (TN 4160)*

PART 2—EFFECT OF CYCLE THERMAL STRESSING ON THE STRESS-RUPTURE LIFE AND DUCTILITY OF S-816 AND INCONEL 550. *(TN 4165)*

Welding symbols WELDING SYMBOLS. *1958. 87 pp. American Welding Society, 33 W. 39th St., New York 18. Price $3 (AWS A2.0-58)*

Symbols are given for: 1) spot and seam welds made by arc welding, 2) welds used in aircraft, guided missiles and automobiles, and 3) welds used in structural steel fabrications and reinforced concrete. Included is a new system for designating welding and cutting processes by means of letters.

Uses of beryllium BERYLLIUM FOR STRUCTURAL APPLICATIONS: A REVIEW OF THE UNCLASSIFIED LITERATURE. *Webster Hodge. Aug '58. 207 pp. Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio. (Report No. 106)*

Summarizes available information on beryllium and contains recent data which may help in evaluating the usefulness of the metal as a structural material in airframe and missile applications. Problems in industrial hygiene encountered in working with beryllium are reviewed briefly.

Corrosion of titanium CHEMICAL AND GALVANIC CORROSION PROPERTIES OF TITANIUM ALLOYS. *C. B. Kenahan and David Schlain. 1958. 27 pp. U. S. Dept. of the Interior, Bureau of Mines, Washington 25, D.C. (Report No. 5423)*

Tests show the chemical and galvanic corrosion properties of titanium-base alloys are quite similar to those of unalloyed titanium. Commercially pure titanium resists chemical attack better than titanium-base alloys in dilute hydrochloric acid solutions.

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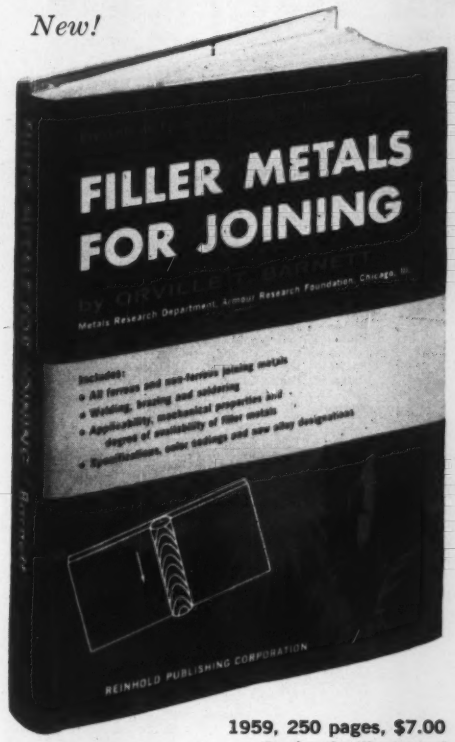

1959, 250 pages, $7.00
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by **ORVILLE T. BARNETT,**
Metals Research Department,
Armour Research Foundation, Chicago, Illinois

This much-needed reference presents reasons for, and summarizes industrial practice in selecting the proper filler metal for any metal joining situation. It covers all of the ferrous and non-ferrous joining metals. Welding, brazing and soldering are treated with major emphasis on products for manual and automatic arc welding. Available materials are discussed in terms of applicability, mechanical properties and degree of availability. Where many filler metals are offered for a single application, factors controlling the best choice are outlined.

The book supplements the many excellent specifications prepared by the American Welding Society in cooperation with the American Society of Testing Materials, and includes the National Electrical Manufacturers Association color codings and new alloy designations of the Aluminum Association.

Ten chapters are devoted to arc welding electrodes, and another to automatic welding of mild and low alloy steels which discusses materials in an area where no specifications exist as yet. The chapters on new iron powder electrodes, latest developments in non-ferrous metals, surfacing and tungsten electrodes contain much material that has never been published before.

Over 84 experts in the field of joining reviewed portions of the text and made many pertinent and useful suggestions.

Here is a handy reference for welding engineers, designers, and welders who are interested in knowing when and where to use individual filler metals; for purchasing agents who want to look up competing products; and for anyone in welded fabrication who needs to choose among the great variety of products being marketed.

CONTENTS

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E6013 Electrodes
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E6020-E6030 Electrodes
Iron Powder Electrodes for Mild Steel
Low-Alloy High-Strength Electrodes
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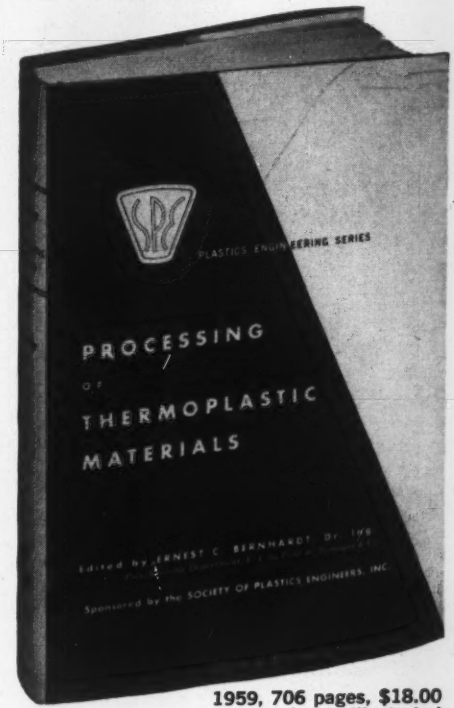

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About the Editor

ERNEST C. BERNHARDT supervises process development activities at the Sales Service Laboratory of the Polychemicals Department, E. I. du Pont de Nemours and Company, Inc. His technical publications have been primarily in the field of thermoplastics extrusion. He is a member of the Society of Plastics Engineers, and of the American Chemical Society. He received a B.S. in Chemical Engineering from Purdue University, his M.Ch.E. from the University of Delaware, and a Doctorate in Engineering from the TECHNISCHE HOCHSCHULE in Darmstadt, Germany.

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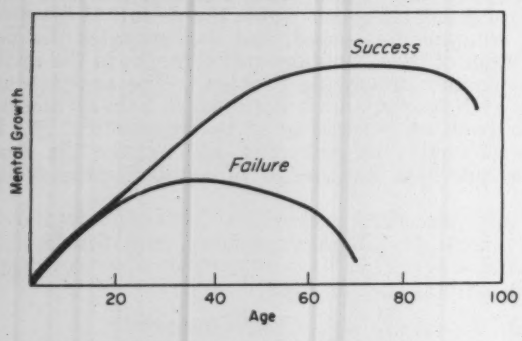
The First Five Years Are the Toughest

THE LAST WORD

by H. R. Clauser
Editor

Not more than one out of every five people ever reaches his mental potential. The rest follow the "failure" curve shown in the accompanying chart. This is the considered opinion of Dr.



Joseph W. Still, based on nine years of research in gerontology (the study of aging).

Whether one spends his life on the failure or on the success curve is largely up to the individual. So, the question we should ask ourselves is: "Which curve am I on?"

The critical period

If you have finished college in the past few years, this question is of particular importance. For, it is widely recognized that the most critical period in a man's intellectual growth is the first five years after he has finished his formal education.

As the curves show, our mental growth continues steadily through college and early adult life. This steady growth is largely due to the fact that during these years our education is planned for us and the degree serves as a tangible goal. But after graduation, we are on our own. We no longer have the disciplines of college or a regular curriculum to guide our development. Too often this leads to a post-graduate slump.

Six suggestions

To avoid this slump and thus stay on the upper growth curve, the individual engineer must undertake his own program of mental and professional development. The Engineers' Council for Professional Development suggests that such a program cover six main points. They are:

1. Orientation and Training in Practice. Where offered, take advantage of the opportunities and experience to be gained from formal or informal training programs. They provide a valuable foundation on which to begin your self-development.

2. Continuing Education. Take advantage of the many available educational facilities to further your knowledge in the basic principles of engineering and science. Also devote some time to study in the humanities and to develop your speaking and writing abilities.

3. Selected Reading. Start a well-rounded reading program to expand your technical and cultural knowledge. And keep up to date on technical developments by regularly reading the magazines in your fields of interest. Two reading lists are available from the ECPD. They are "Reading List for Young Engineers" and "Selected Bibliography of Engineering Subjects."

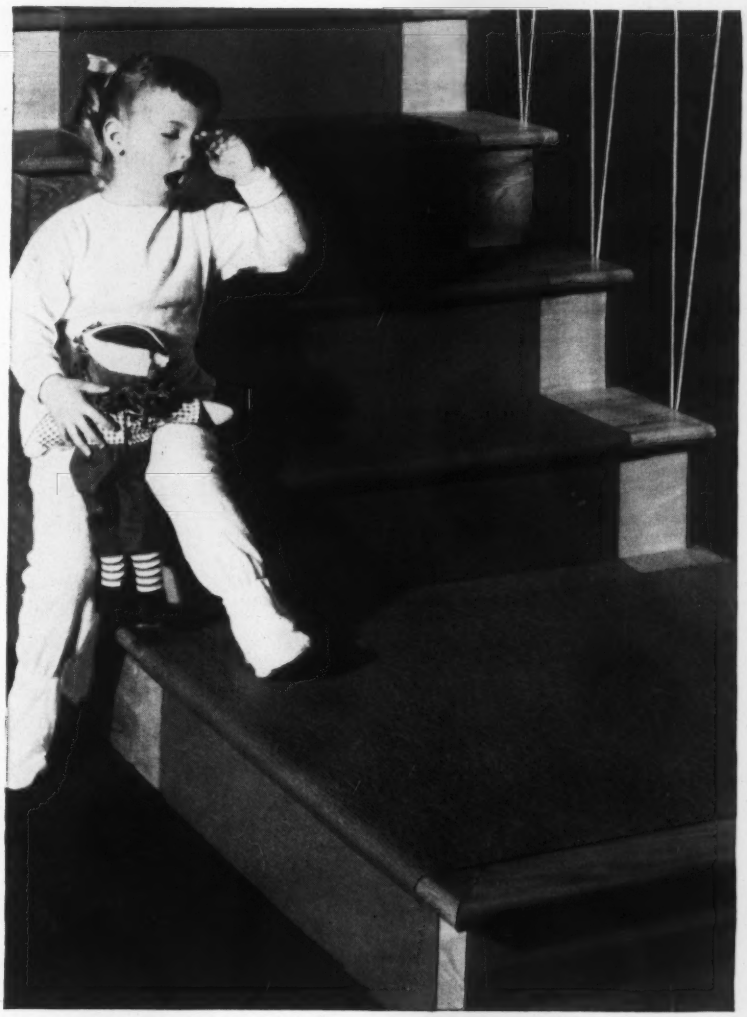
4. Professional Identification. Join and become active in professional or technical societies in your field of engineering activity.

5. Responsible Citizenship. Participate in community activities. Civic leadership often goes hand in hand with professional growth.

6. Personal Appraisal. Periodically, take stock of your mental growth, your accomplishments, your technical competence and your current position to determine whether or not you are using your abilities to the fullest extent. A Personal Appraisal Questionnaire is available from ECPD to help you make such a personal analysis.

Although these six principles were developed to help the young engineer, they have a broader application. They are the elements of the program that must be followed, even after those first critical post-graduate years, if you are to stay on the upper curve of mental growth and success.

How a new Ameripol Rubber cushions costs, helps "Carpetreds" step up quality



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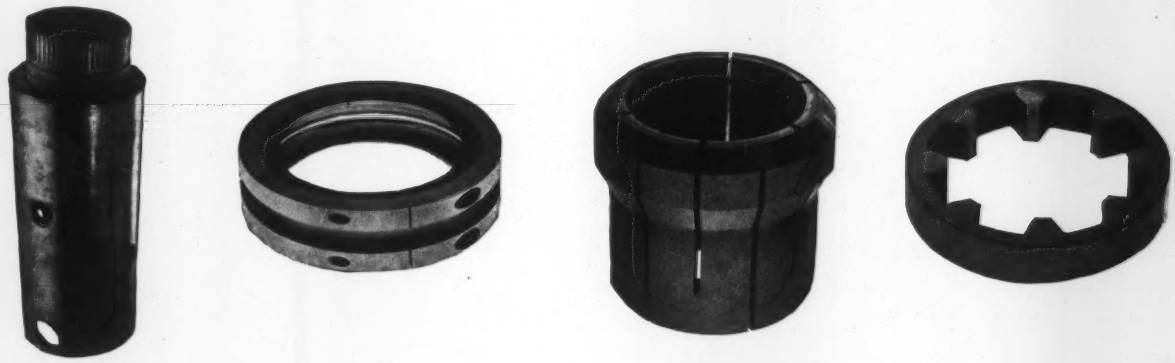

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